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SAND RESOURCES OF SOUTHERN LAKE ERIE, CONNEAUT TO TOLEDO, OHIO --ETC(U)
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Sand Resources of Southern Lake Erie, Conneaut to Toledo, Ohio - A Seismic Reflection and Vibracore Study

by

S. Jeffress Williams, Charles H. Carter,

Edward P. Meisburger, and Jonathan A. Fuller

MISCELLANEOUS REPORT NO. 80-10

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

About 2,250 square kilometers of the Lake Erie bottom between Conneaut and Toledo, about 25 percent of Ohio's open lake part of Lake Erie, was surveyed to assess potential sand and gravel resources. Primary survey data consist of 690 kilometers of high-resolution seismic reflection profiles between Conneaut and Toledo; 58 vibracores with a maximum length of 6.1 meters were also taken between Conneaut and Marblehead, Ohio. Survey limits were generally from the -7.5-meter depth contour to about the -14-meter depth contour, a maximum of about 16 kilometers offshore.

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The objectives of this survey were to acquire additional information, primarily subbottom data from known sand deposits along the south shore of Lake Erie, and to investigate the areas between the known sand deposits for undiscovered sand and gravel resources.

Sizable sand deposits of more than 10 million cubic meters exist at four areas. Sand in two of the areas, Fairport Harbor and Lorain-Vermilion, has the highest potential for beach restoration projects. The Fairport Harbor deposit, ~~an elongate~~ topographic high which extends about 10 kilometers offshore, is estimated to contain about 146 million cubic meters of fine- to medium-grain sand. The Lorain-Vermilion deposit starts about 9.5 kilometers offshore and is estimated to contain about 32 million cubic meters of fine to coarse sand in the inshore part of the deposit investigated in this study. The Cedar Point area, at the mouth of Sandusky Bay, contains about 13 million cubic meters of very fine and fine grain sand; the Maumee Bay area contains about 49 million cubic meters of primarily fine grain sand. The fine grain size of the Cedar Point and Maumee Bay deposits probably will restrict their use for beach restoration.

Cores taken outside of the sand deposit areas generally contain modern lacustrine mud or silt at the surface except in areas where till is exposed. A few cores contained sand at depth but the overlying fine-grained sediment and the lack of areal continuity make them undesirable as sand deposits for beach restoration and nourishment.

PREFACE

This report on sand resources of southern Lake Erie is one of a series which presents results of the Inner Continental Shelf Sediment and Structure (ICONS) study. The primary objective of the ICONS program is to locate and delineate offshore sand and gravel deposits suitable for beach nourishment and restoration. The work was carried out under the coastal processes program of the U.S. Army Coastal Engineering Research Center (CERC), in cooperation with the Ohio Department of Natural Resources, Division of Geological Survey (ODGS).

The report was prepared by S. Jeffress Williams and Edward P. Meisburger, under the general supervision of Dr. C.H. Everts, Chief, Engineering Geology Branch, CERC; and by Charles H. Carter and Jonathan A. Fuller, under the general supervision of H.R. Collins, Chief, ODGS. Data collection was conducted by CERC and ODGS with the assistance of U.S. Army Engineer Districts, Buffalo and Mobile, and the U.S. Army Engineer Waterways Experiment Station (WES).

The authors acknowledge the assistance of the following people: J. May, J. Forbes, and D. Andrews (WES) who operated the seismic reflection equipment; E. Lagrone (Mobile District) who operated the vibracore equipment, and M. Chambers (Buffalo District) who skippered the tug and scow for the vibracore operation; D.L. Liebenthal (ODGS) who skippered the boat carrying the seismic reflection equipment and the navigation system; D.E. Guy, Jr., C.L. Hopfinger (who also helped with the laboratory work on the vibracores and with the data compilation), T.J. Feldkamp, J.D. Reed, and J. Vormelker (ODGS) who positioned the transponders for the Mini Ranger; D.A. Prins (CERC) who was field survey chief during both data collection phases and D.J. Benson (ODGS) who helped plan the surveys and collect the seismic records. The constructive reviews and comments by Dr. C.H. Everts and H.R. Collins are also appreciated.

Original copies of all seismic data are stored at CERC. Cores collected during the field survey in Ohio are in a repository at the University of Toledo, Toledo, Ohio, under agreement with CERC. Requests for information relative to these items should be directed to CERC or the Department of Geology, University of Toledo.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

Ted E. Bishop

TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

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CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

SAND RESOURCES OF SOUTHERN LAKE ERIE, CONNEAUT TO TOLEDO, OHIO - A SEISMIC REFLECTION AND VIBRACORE STUDY

by

S. Jeffress Williams, Charles H. Carter, Edward P. Meisburger, and Jonathan A. Fuller

I. INTRODUCTION

1. Background and Scope.

The construction, improvement, and periodic maintenance of beaches and dunes by placement of suitable sand along the shoreline is an effective means of counteracting coastal erosion and of enhancing coastal recreational facilities. In recent years, it has become increasingly difficult to obtain large volumes of suitable sand from bays and inland sources because of diminishing resources as well as economic and ecological factors. Accordingly, the Coastal Engineering Research Center (CERC) initiated an Inner Continental Shelf Sediment and Structure (ICONS) study to locate offshore sand resources suitable for beach fill (Duane, 1968). This report, the second ICONS study on the Great Lakes (the first was in southeastern Lake Michigan; Meisburger, Williams, and Prins, 1979), deals with offshore sand deposits along the Ohio shore of southern Lake Erie, mapped from seismic reflection profiles between Conneaut and Toledo and from vibracores taken between Conneaut and Marblehead. It differs from previous ICONS studies in that it was conducted in cooperation with the Ohio Department of Natural Resources, Division of Geological Survey (ODGS). The subbottom geology of this area is covered in a complementary report by Carter, et al. (in preparation, 1980). The Pennsylvania shore of Lake Erie, particularly the Presque Isle region near Erie, is discussed in another report (Williams and Meisburger, in preparation, 1980).

The study area encompasses a zone ranging from 1 to 16 kilometers offshore between Conneaut and Toledo (Fig. 1). Survey coverage of the area is shown in

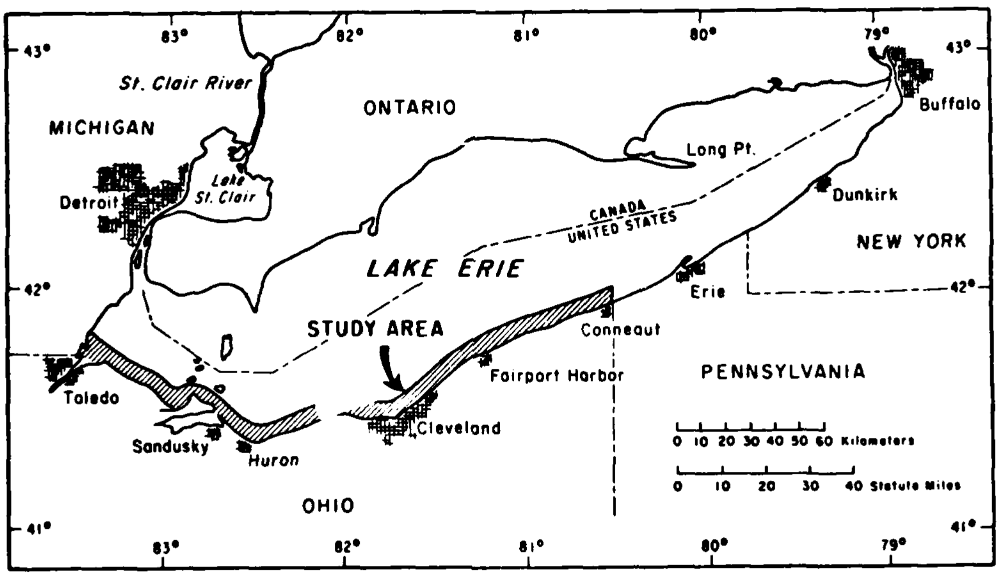


Figure 1. Lake Erie study area. Seismic reflection tracklines and core locations from Conneaut to Toledo, Ohio, are shown in Figures 2 to 8.

Figures 2 to 8 (an investigation of the sand impounded by major harbor structures such as the Huron and Fairport Harbor jetties is not included in the survey). Data consist of 690 kilometers of reflection profiles (taken in August 1977) and 58 cores (taken in August 1978) ranging from 0.67 to 6.1 meters in length. About 25 percent of Ohio's open lake part of Lake Erie (8,960 square kilometers) was covered by the seismic reflection survey. These data were supplemented by previously published lake studies. Vertical control was obtained from National Ocean Survey (NOS) water level gage data; water depths are referenced to low water datum (LWD), 173.3 meters above mean water level at Father Point, Quebec (International Great Lakes Datum, 1955) for Lake Erie. Mean lake level in both August 1977 and 1978 was about 1 meter above LWD.

This report is basically a reconnaissance effort; seismic line spacing and orientation and core spacing density preclude a detailed evaluation of the nature of the offshore sand deposits. However, the more detailed seismic reflection line spacing and the greater number of vibracores collected in the Fairport and Lorain-Vermilion areas allow general estimates to be made of the sand volumes of these areas.

2. Geographic and Geologic Setting.

The shore from Toledo to Conneaut is characterized by a flat to gently rolling terrain which slopes to the north and is dissected by many rivers and creeks which flow toward Lake Erie. The principal rivers are the Maumee, the Toussaint, the Portage, the Sandusky, the Huron, the Vermilion, the Black, the Rocky, the Cuyahoga, the Chagrin, the Grand, the Ashtabula, and the Conneaut, some of which have major harbors at their mouths. A large part of the shore is developed, particularly the densely populated area between Cleveland and Sandusky which consists mostly of urban and suburban communities.

Shore deposits consist primarily of glacial drift and lacustrine clay; rock is exposed along the shore at Marblehead and along much of the shore between Vermilion and Cleveland. These deposits have formed banks, slopes, and bluffs that average about 10 meters in height, and range from the 1-meter-high clay banks near Toledo to the 21-meter-high till bluffs near Conneaut. Beaches which front the shore are generally narrow (<15 meters wide) and are commonly discontinuous because of limited sand in the littoral system due to manmade structures or natural deficiencies. Just offshore, the lake bottom slopes are gentle and water depths 100 meters from the shoreline are generally no more than -2 meters. The nearshore lake bottom is commonly composed of bedrock, till, or sand. Farther offshore the bottom is nearly flat, covered mostly by glacial and postglacial fine-grained lacustrine deposits.

3. Previous Studies.

Verber (1957) and Hartley (1961) conducted the first comprehensive studies of bottom sediments off the Ohio part of the central and western Lake Erie basins. Bottom grab samples were taken on 1.6- or 3.2-kilometer grids, with some subbottom sampling by coring or jetting. Detailed echo sounding and bottom sampling to a depth of about 1.0 meter had previously been done in the Lorain-Vermilion and Fairport Harbor sand dredging areas in a cooperative effort by the U.S. Army Corps of Engineers and ODGS (Beach Erosion Board, 1952). The shore and nearshore deposits within about 600 meters of the shoreline were also mapped in the 1970's by ODGS as part of their county shore erosion studies (e.g., Carter, 1976, and Benson, 1978).

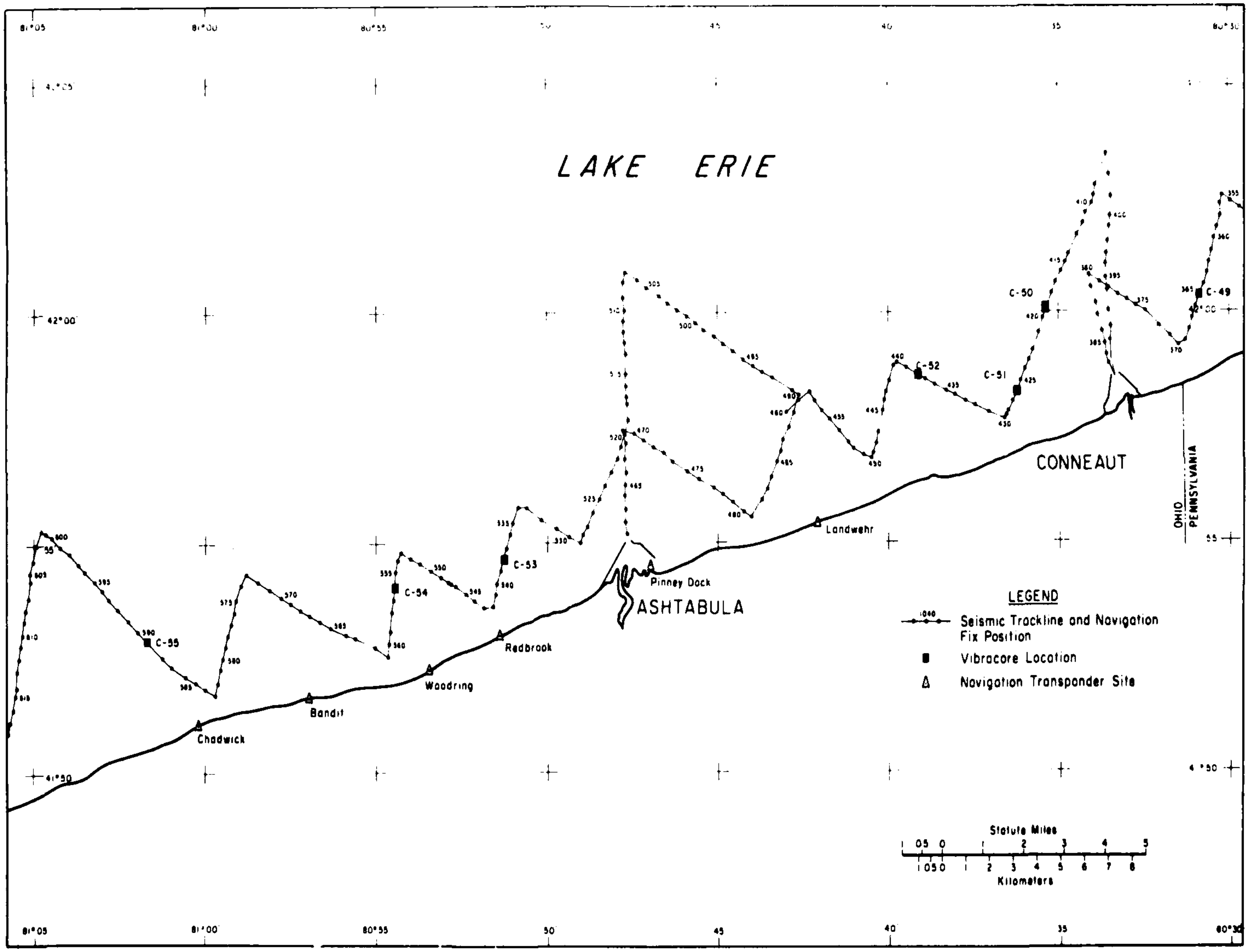


Figure 2. Trackline location map, Ohio-Pennsylvania State line to east of Fairport Harbor.

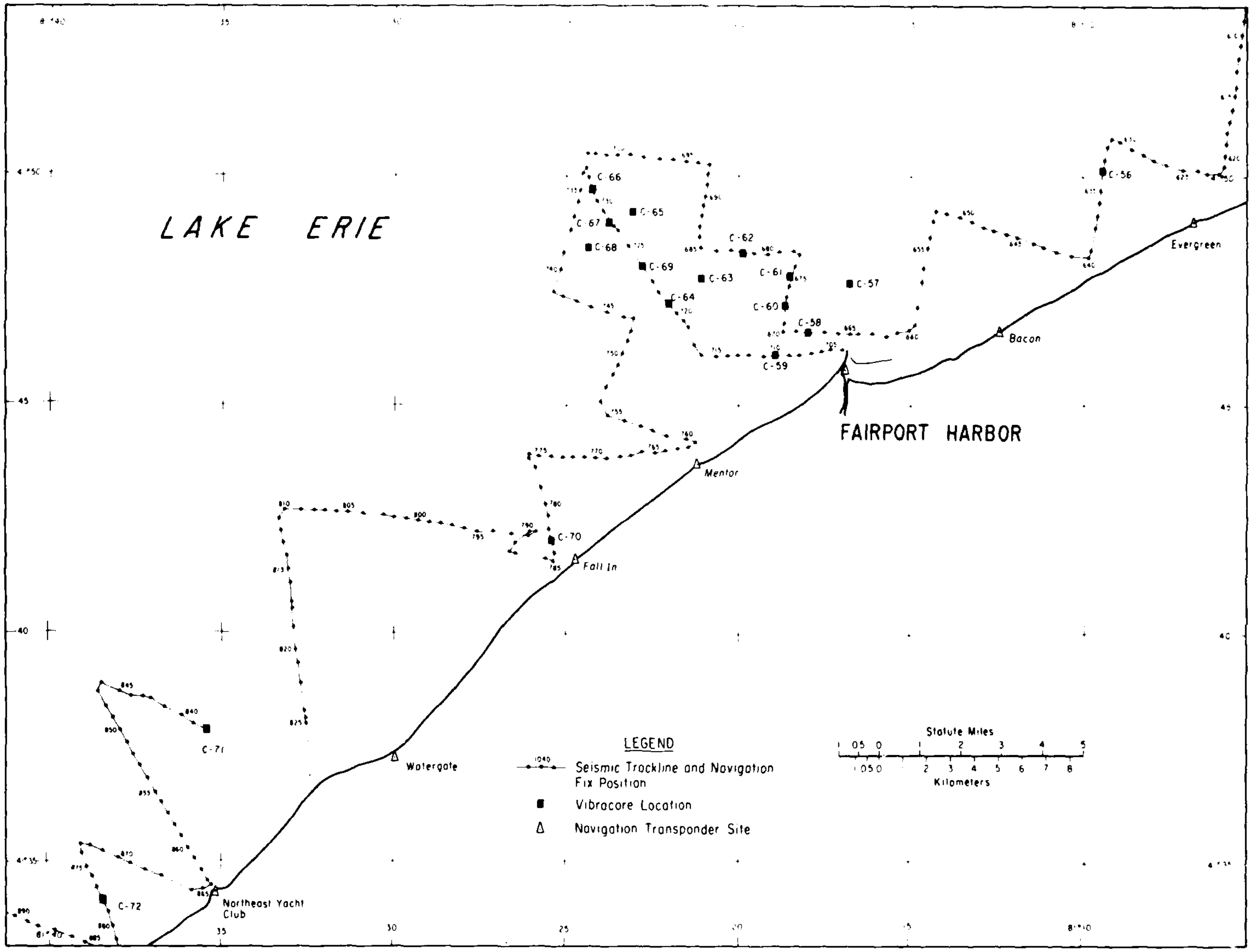


Figure 3. Trackl'ne location map, East of Fairport Harbor to Northeast Yacht Club.

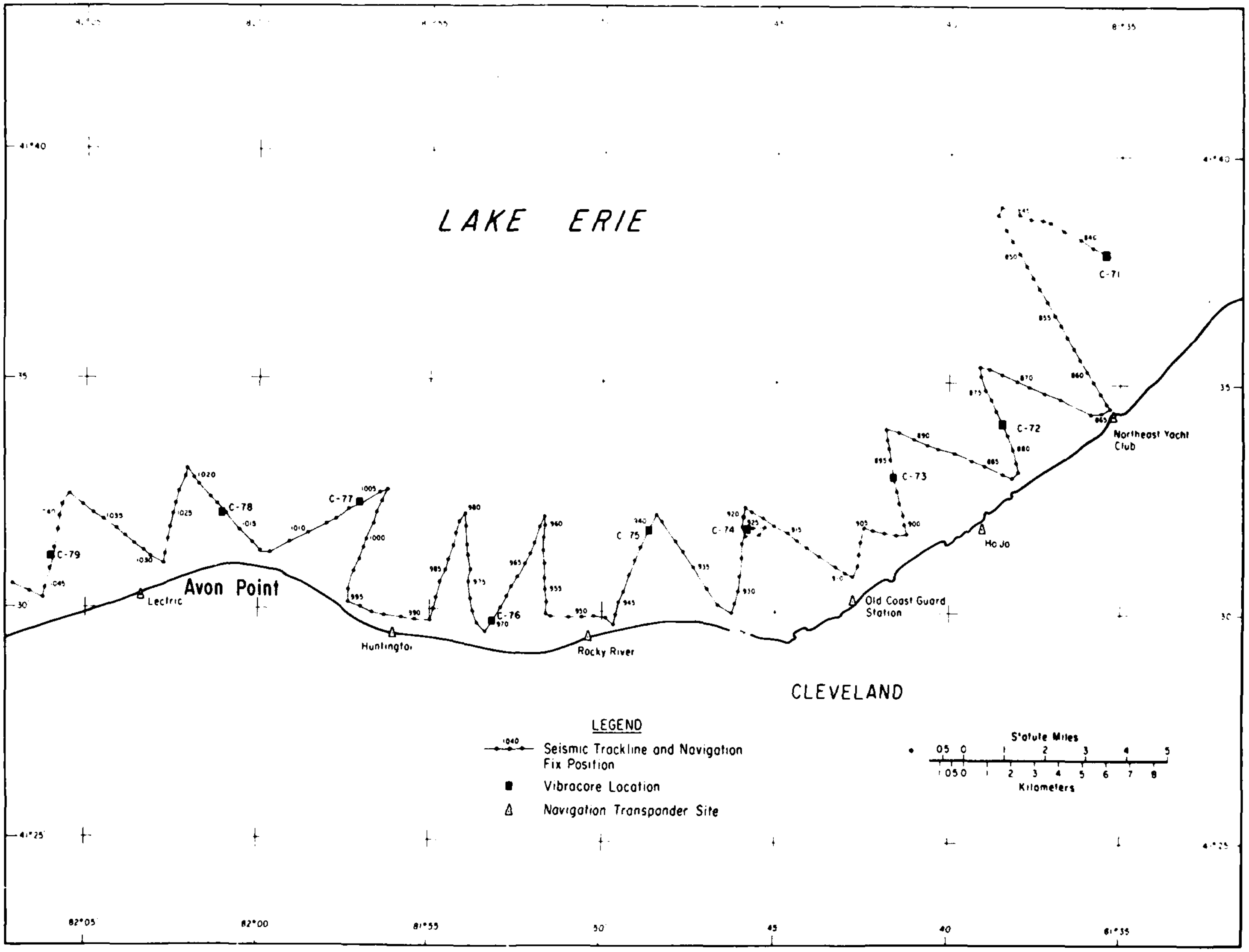


Figure 4. Trackline location map, Northeast Yacht Club to Avon Point.

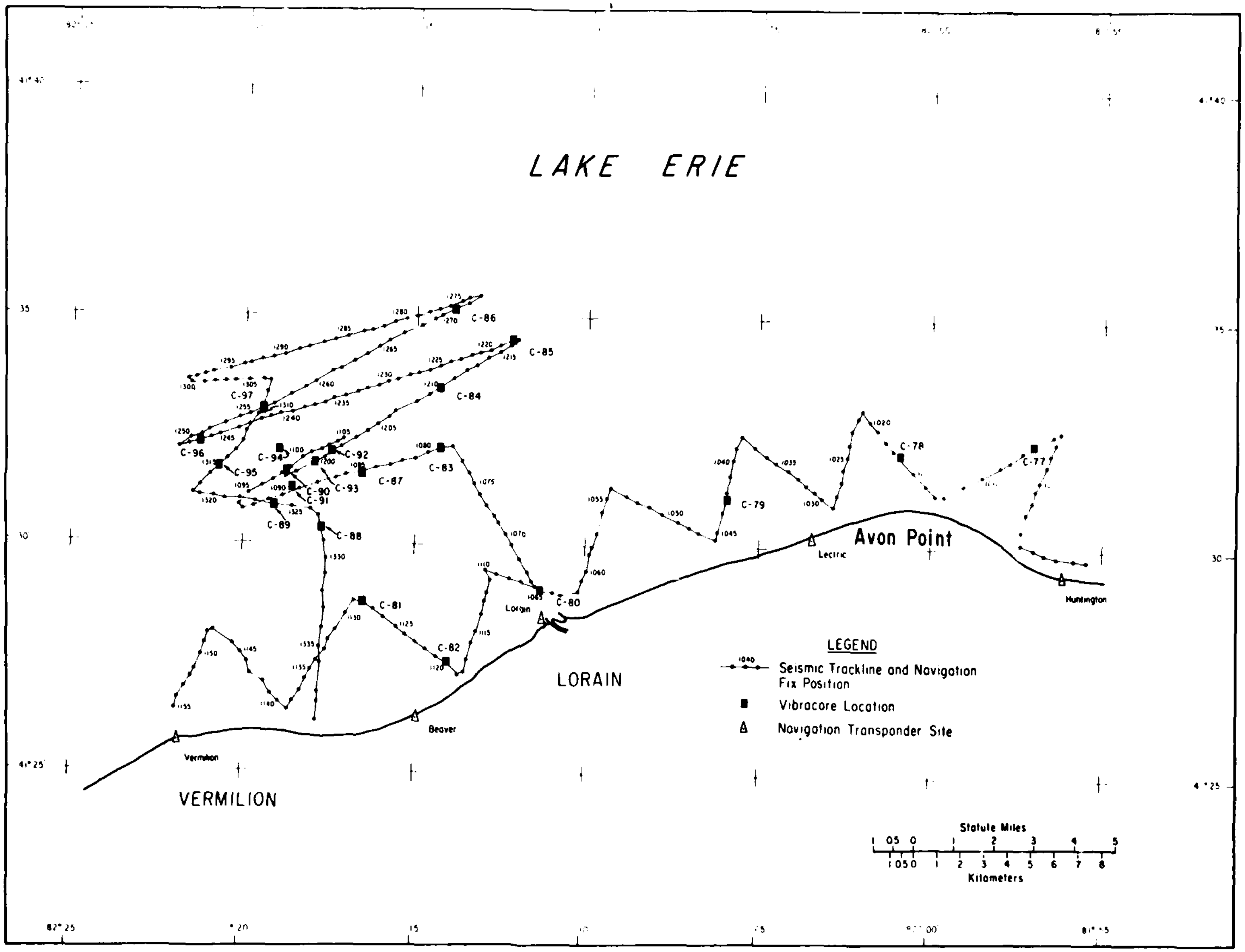


Figure 5. Trackline location map, Avon Point to Vermilion.

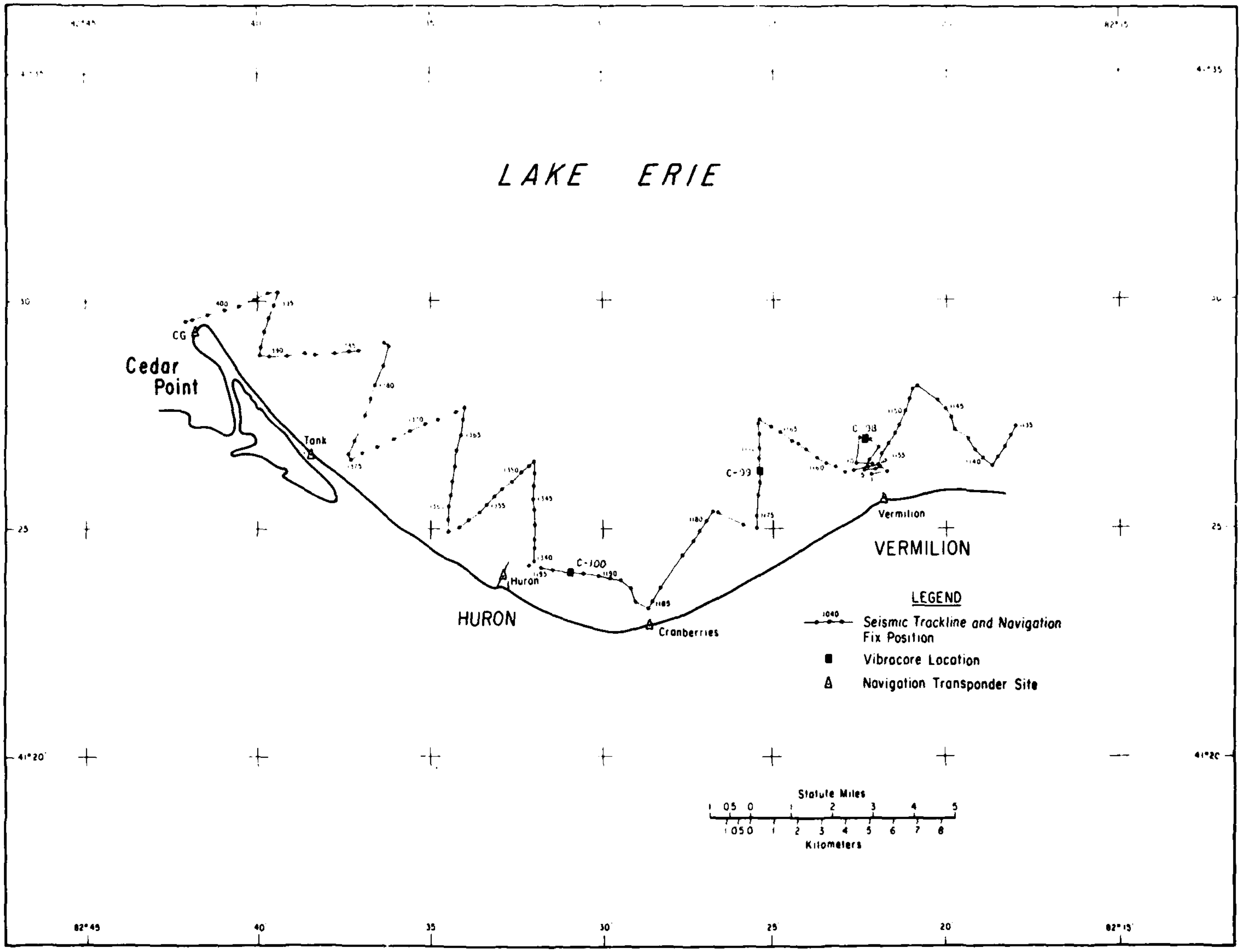


Figure 6. Trackline location map, Vermilion to Cedar Point.

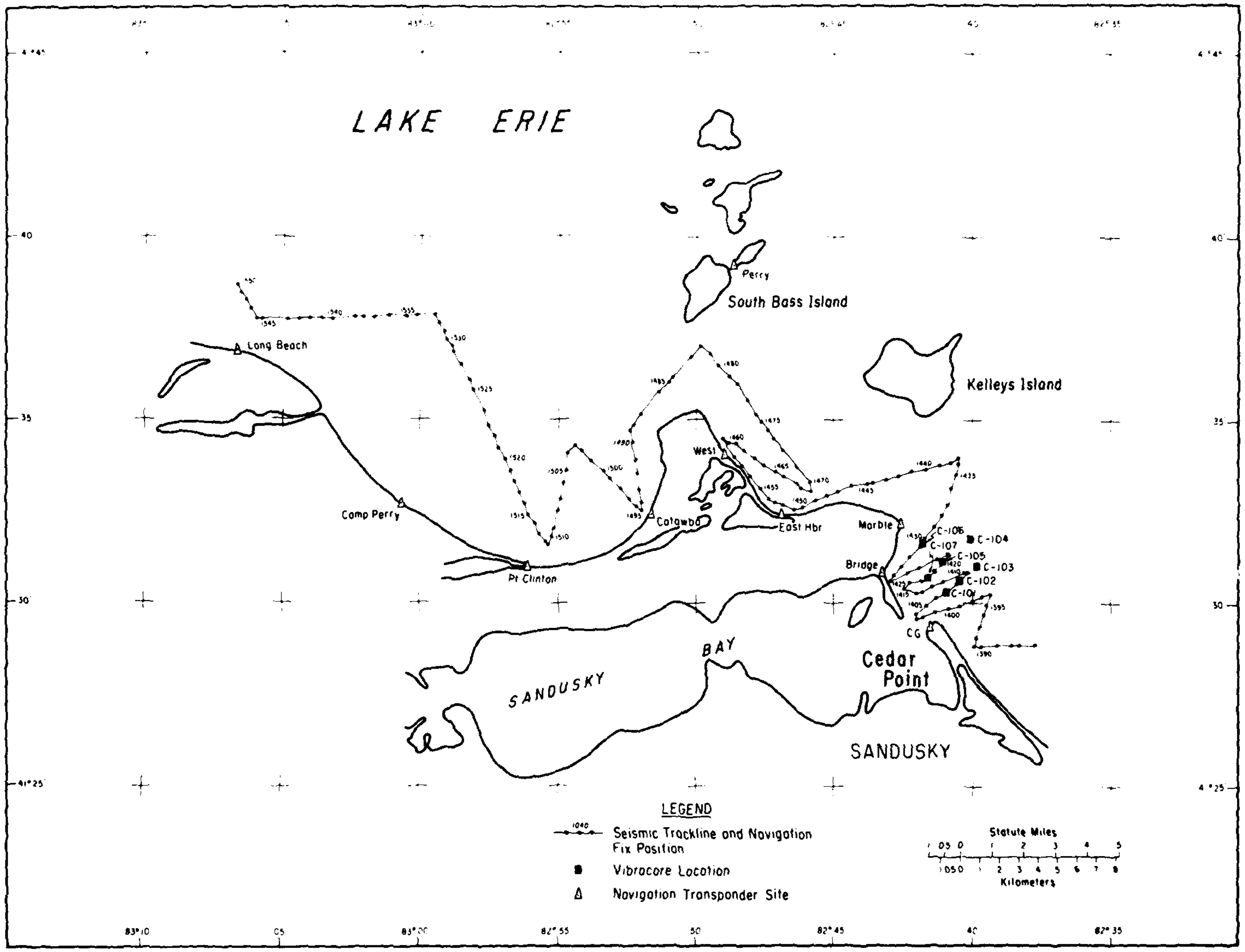


Figure 7. Trackline location map, Cedar Point to Long Beach.

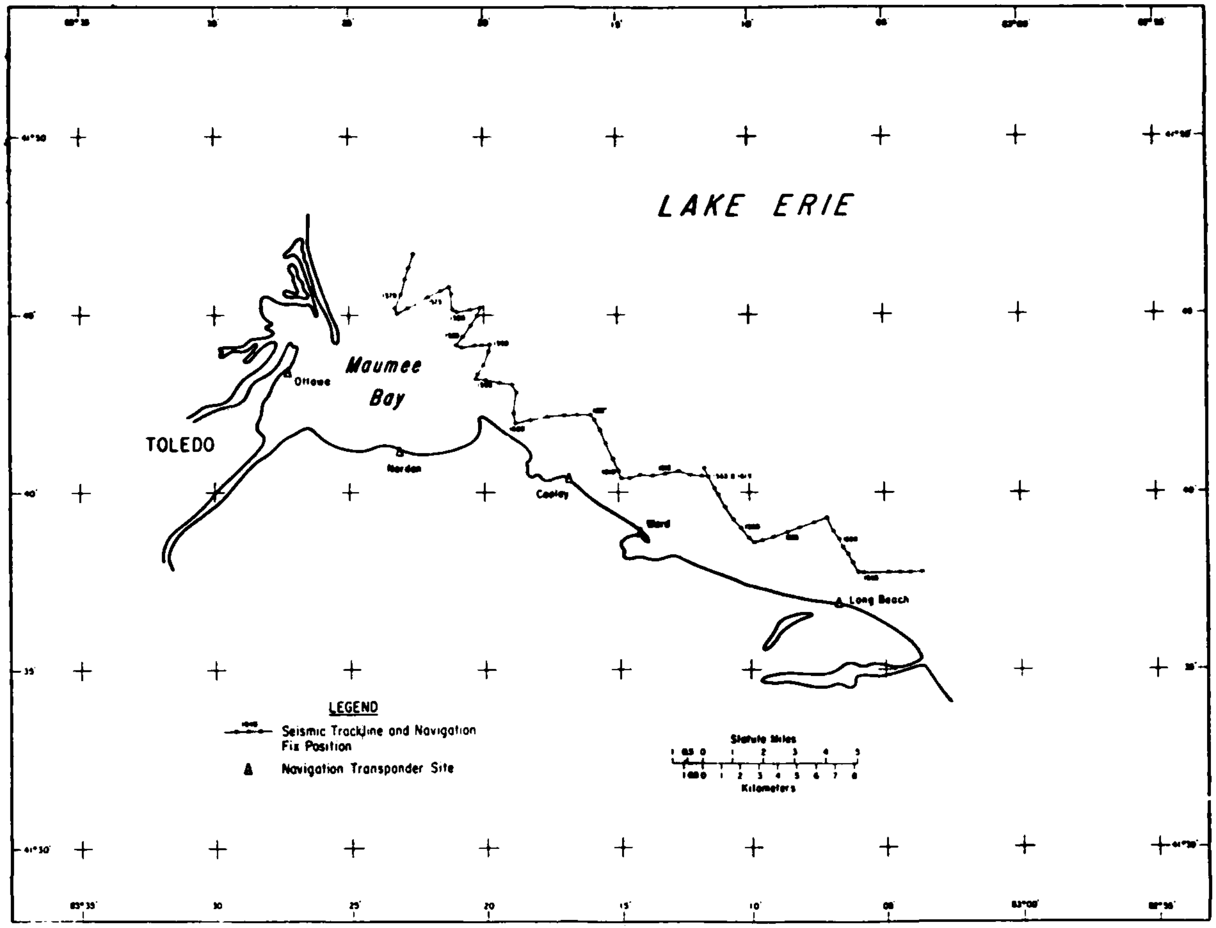


Figure 8. Trackline location map, Long Beach to Maumee Bay.

Two shallow seismic reflection surveys of central Lake Erie have been published by Morgan (1964) and by Wall (1968). However, Wall's structure contour maps are too general to provide much information on sand deposits, and Morgan's maps of three reflectors (bedrock, the sediment-water interface, and a reflector intermediate between bedrock and the lake bottom) are also too general.

A comprehensive study of the known sand and gravel deposits within the Ohio part of Lake Erie was done by Hartley (1960) between 1953 and 1957. In addition to detailed echo sounding and bottom sampling, 100 holes were jetted in and near the three Central Basin sand deposits (Cedar Point, Lorain-Vermilion, Fairport Harbor), and 48 holes were jetted in the Western Basin deposit (Maumee Bay). Subsequent sampling and echo sounding were done off Ashtabula, Conneaut, Huron, and Sandusky, and in the island area (Herdendorf and Braidech, 1972). The work by Hartley provided important data that were extensively used in the planning stages of this study.

Several hundred kilometers of seismic reflection profiles and 32 borings and cores were collected in a rectangular nearshore area off Cleveland as part of an engineering feasibility study for a proposed airport facility on a manmade island (Dames and Moore, 1974).

II. EQUIPMENT AND FIELD AND LABORATORY PROCEDURES

1. Geographic Positioning System.

A radar-type electronic positioning system, the Motorola Mini-Ranger III, was used to determine position of the research survey vessels during the seismic survey (phase I) and the vibracoring (phase II). The system determines the position of the survey vessel with respect to two known reference points on shore and is restricted to line-of-sight operation (the stated accuracy is ±3 meters). The basic system consists of a master mobile unit mounted aboard the vessel and two shore-based transponders. The master unit triggers reply pulses from the transponders; each transponder pulse is received separately and the elapsed time between the transmitted pulse and the individual transponder reply pulse is converted to a measurement of distance. Each distance (range) from the two transponders at the known shore stations is displayed, in turn, on the range console. This range information, together with the known locations of the shore stations, is then trilaterated and plotted on hydrographic charts to obtain the position (fix) of the survey vessel. Navigational fixes during the seismic survey were obtained about every 2 minutes and each fix was keyed to the seismic records by an event mark on the records.

2. Seismic Reflection Profiling.

Seismic reflection profiling is a technique widely used for delineating geologic features such as bedding surfaces, faults, rock outcrops, channels, and structures beneath the lake floor. Continuous reflections are obtained by generating repetitive, high-energy, sound pulses near the water surface and at the same time recording "echoes" from the lake floor-water interface and from subbottom interfaces between acoustically dissimilar materials. This is done while the survey vessel is moving. In general, the compositional and physical properties (e.g., porosity, water content, relative density) which commonly differentiate sediments and rocks also serve to produce acoustic contrasts which show as dark lines on the seismic paper records.

The seismic reflection data were obtained by towing sound-generating and -receiving instruments behind the ODGS Research Vessel *GS-1* (Fig. 9) which followed predetermined survey tracklines (Figs. 2 to 8). In phase I of this study, two seismic subbottom profiling systems were used simultaneously. An Ocean Research Equipment, Inc. (ORE) 3.5-kilohertz pinger system was used to gain high resolution of the upper 10 meters of lake floor; an Edgerton, Gremerhausen and Greer (EG&G), Inc. UNIBOOM system operating on 300 joules of energy was used to decipher geologic conditions to depths from 0 to about 30 meters below the lake bottom. Data from each system complement the other and were used to achieve maximum understanding of the subbottom geologic character. A vertical scale on the profiles was determined from a sound velocity of 1,550 meters per second in water and 1,800 meters per second for typical sandy sediment. Actual velocities will vary depending on sediment properties but 1,800 meters per second was found to be a reliable average value for sand. Additional information on various seismic profiling techniques is discussed in Ewing (1963), Moore and Palmer (1967), Barnes, et al. (1972), and the American Association of Petroleum Geologists (1977).

Figure 9. The ODGS Research Vessel *GS-1* used to tow the seismic equipment and locate core sites.

3. Coring Equipment.

A pneumatic vibratory coring device designed to obtain continuous sediment cores a maximum of 6.1 meters long was used in the phase II survey operation (Fig. 10). The apparatus is equally effective in penetrating and recovering granular and cohesive sediments; however, the core barrel will not penetrate consolidated rock or pebbly till. The core rig consists of a 10.1-centimeter steel core barrel, clear plastic inner liner, shoe and core catcher, and a pneumatic driving head attached to the upper end of the barrel. These elements are enclosed in a quadrapodlike frame with four articulated legs which rest on the lake bottom. An aluminum H-beam and frame serve as a support structure and guide for the vibrator head and core pipe as the core barrel penetrates the lake bottom. The lack of rigid attachment of the coring device to the surface vessel allowed limited motion of the vessel during the actual coring processes. Power was supplied to the pneumatic vibrator head by a flexible hoseline connected to a large-capacity (118 liters per second) air compressor. After coring was completed, the assembly was hoisted on board the vessel, the liner containing the core was removed, samples from the top and bottom of the core recovered, the ends sealed, and the core carefully marked for orientation and identification. The historical development of vibratory coring equipment is discussed by Tirey (1972).

A 36-meter-long scow from the U.S. Army Engineer District, Buffalo, was used as the platform for phase II coring. The scow was transported by the Corps tugboat *Washington* (Fig. 11).

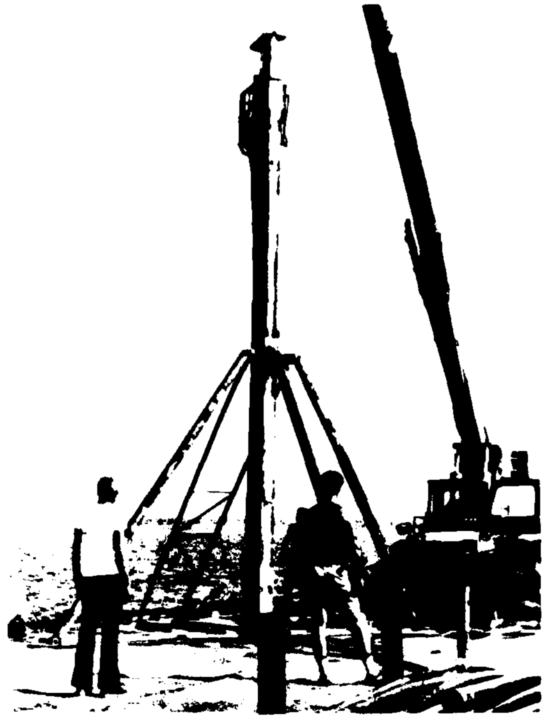


Figure 10. A 6-meter-long vibratory coring apparatus used to collect sediment cores is shown being lifted off the platform for deployment on the lake floor.

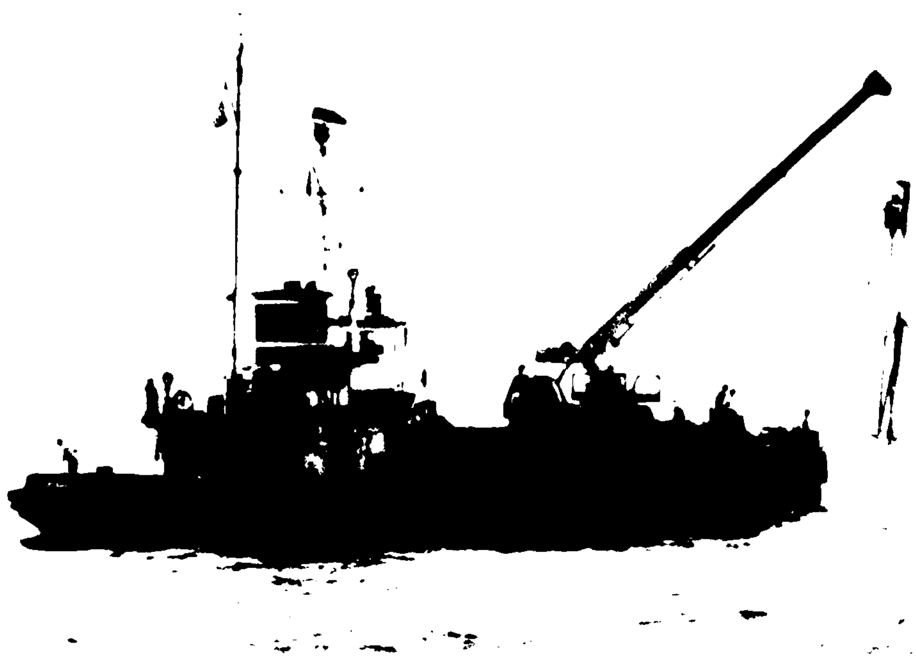


Figure 11. The Corps tug *Washington* and scow used as a coring platform.

4. Data Collection Planning.

Before the field data collection effort, tentative offshore seismic survey tracklines were established and plotted on navigation charts of the survey area. Position, spacing, and length of the tracklines were determined by several factors. The primary factor was spacing the lines to achieve maximum coverage of the study area. In the Central Basin, the inshore boundary averages about 1 kilometer from shore, whereas the offshore boundary averaged about 7 kilometers. Average water depths in the nearshore were about -7.5 meters (about the minimum depth for obtaining good quality seismic profiles), and in the offshore were about -14 meters. In the Western Basin, the inshore boundary averaged about 2 kilometers from shore, whereas the offshore boundary averaged about 5 kilometers. Average water depths in the nearshore were about -5 meters, and in the offshore were -8 meters.

A second factor was to lay out the seismic lines so that geologic features with a high potential for containing sand would be crossed and show on the seismic profiles. Preliminary core sites were selected on the basis of bathymetric information; however, final core sites were chosen after all the seismic data were collected and subjected to preliminary interpretation. After the survey tracklines were selected, the locations of the shore stations for the navigation system were determined. Of high priority were stations at elevated positions (for adequate line-of-sight) which also offered good triangular position in relation to the survey ship and adjacent shore stations. (Acceptable results are achieved when the angle of range intercept of the vessel is greater than 30° and less than 150°; optimum range angle intercept is 90°.) A total of 39 shore navigation stations were used along 284 kilometers of coast between Conneaut and Toledo. Occasionally, positions and spacing of the predetermined tracklines were altered to gather additional information on geologic features such as buried stream channels, sediment contacts, and lake bottom outcrops of possible sandy material.

After seismic profile records were collected, preliminary analyses and interpretations were made to select coring sites with the greatest potential, based on past experience, for finding sand and providing subsurface information. Use of seismic data to decipher geologic conditions before selecting final core sites enables a selection based on the best information available. Thus, this procedure maximizes the usefulness of both sources of data and provides the most efficient use of funds.

During phase II the vessel *GS-1*, with the positioning system aboard, was used to relocate fix positions selected as coring sites by duplicating the range values from the shore stations. The vessel first maneuvered until one of the ranges was duplicated and then an arc was run on that range until the other range was intersected, at which time an anchored float was used to mark the core location. Core sites were located and marked in this manner because of the limited maneuverability of the barge. Without using the *GS-1* to first buoy the core site, much additional time would have been required to maneuver the scow to the precisely determined core locations. The *GS-1* crew located a core position in minutes and dropped a float marker; the tug and scow then moved in on the marker, anchored, and the core rig was lifted from the deck of the scow and set on the lake bottom next to the float. Meanwhile, the vessel proceeded to the next selected core station. Once on the bottom the coring device was energized, the core barrel was driven into the lake bottom, and within about 15 minutes the

coring was complete and the apparatus was lifted back onto the scow. The core liner containing the sediment was removed from the barrel and small representative samples were obtained from the top and the bottom of each core. The liner was then capped and sealed, labeled, and a general core description was made. The scow was then moved to the next coring location. While underway, the coring device was reassembled and loaded with a new liner.

5. Processing of Data.

After completion of both phases of data collection, all the navigational fix marks, ship trackline positions, core sites, and shore stations were plotted to show the coverage within the survey area (Figs. 2 to 8). The seismic records were visually examined and marked to establish the primary geologic features such as regional sedimentary reflectors, erosional unconformities, sediment contacts, and buried stream channels. Selected acoustic reflectors were then mapped to provide areal continuity of horizons considered significant because of their areal extent and relationship to the general structure and geology of the study area. Where possible, the topmost reflectors were correlated with cored sediment to provide a measure of continuity between cores.

The cores were visually inspected and described in general terms onboard the scow; a more detailed study of the cores was made later. All cores were split longitudinally to show changes in sediment composition, texture, and physical character. Selected intervals of cores were photographed to provide an archive record of the sediment character. The sediments were identified, logged, and described according to textural properties (using the Wentworth Scale in Table 1), gross lithology, color, strength, thickness, fossils, and depth from the lake bottom (top of the core) (see App. A). Representative sediment samples from each core were examined with a plane, light binocular microscope. A total of 291 grain-size analyses were made. Granulometric parameters (e.g., mean grain size, sorting, cumulative size distribution) were evaluated for 141 of the samples by using the CERC Rapid Sediment Analyzer (RSA) as described in the Shore Protection Manual (SPM) (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1977). These RSA data, as well as sieve data from 11 samples too coarse to process by RSA, are presented in Appendix B. Cumulative distribution curves are also presented.

All of the sand sample sizes are described in both millimeters and phi (ϕ) units where $\phi = -\log_2 D$. D is the grain-sized diameter in millimeters (see Table 1). In the RSA analysis the sand sample falls through a tube of water and a pressure transducer is used to determine the fall velocity of the sand grains. A computer program is then used to compute moments for converting fall velocity to hydraulic grain-size diameter. The RSA method is fast and reliable, but it is limited to analyzing very fine to medium sands. Any fine-grained material present with the sand often remains in suspension in the tube when the measurements are stopped. Thus, the silt and clay fraction in a muddy sand sample is often omitted from the size analysis results, making the sample appear better sorted than it actually is. Most researchers agree that RSA values are consistent and slightly coarser than sieve values for identical samples. Ramsey and Galvin (1977) suggest adding 0.33 phi to the RSA mean to obtain the equivalent sieve mean; another formula, with a similar constant, is shown in Appendix B.

Eleven samples which were estimated to have more than 10 percent gravel were sieved at a 0.5-phi interval. Five sand samples from cores 101, 102, and

Table 1. Grain-size scales-soil classification (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1977).

Unified Soils Classification	ASTM Mesh	mm Size	Phi Value	Wentworth Classification
COBBLE				BOULDER
		256.0	-8.0	
				COBBLE
		76.0	-6.25	
COARSE GRAVEL				
		64.0	-6.0	
				PEBBLE
		19.0	-4.25	
FINE GRAVEL				
	4	4.76	-2.25	
SAND coarse				
	5	4.0	-2.0	
				GRAVEL
	10	2 0	-1.0	
SAND medium				SAND very coarse
	18	1.0	0.0	
				coarse
	25	0.5	1.0	
				medium
	40	0.42	1.25	
SAND fine				
	60	0.25	2.0	
				fine
	120	0.125	3.0	
				very fine
	200	0.074	3.75	
SILT				
	230	0.062	4.0	
				SILT
		0.0039	8.0	
CLAY				CLAY
		0.0024	12.0	
				COLLOID

103 in the Cedar Point area were analyzed using a visual accumulation tube (U.S. Interagency Committee on Water Resources, 1958; Guy, 1969); 134 samples with more than a trace of silt or clay were analyzed by the pipet method (Folk, 1974). All these data are included in Appendix B.

III. SAND DEPOSITS

1. Introduction.

The vibracore and seismic reflection data obtained during this study (in addition to the reports of known sand and gravel deposits by the Beach Erosion Board, 1952, and by Hartley, 1960) indicate that sand in sizable quantities is present in at least four areas. The areas (Fig. 12) are divided into two large deposits and two small deposits. The large deposits, Fairport Harbor and Lorain-Vermilion, consist of reasonably thick, relatively deepwater deposits whose areal extents are generally well defined; the small deposits at Cedar Point and Maumee Bay consist of fine-grained, shallow-water deposits which are close to shore. Pertinent information on the large deposits is shown in Table 2.

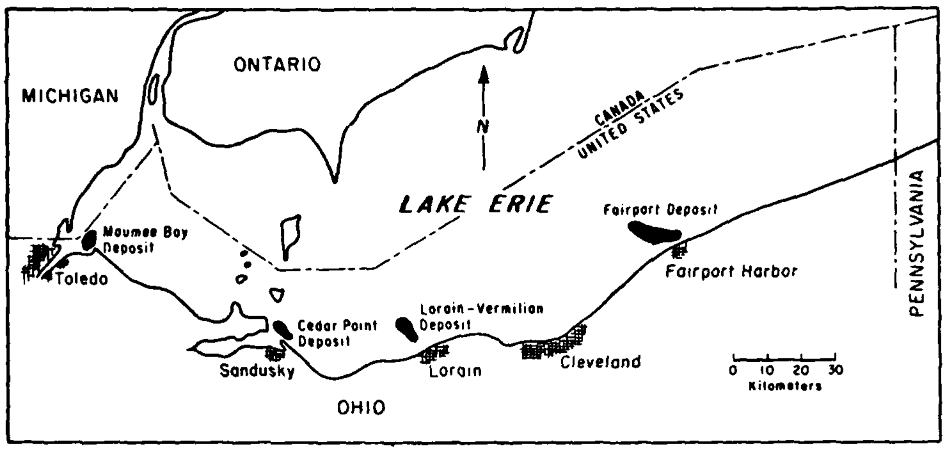


Figure 12. Location of sand and gravel deposits in study area.

Table 2. Sand volume summary.

	Water depths (m)	Cores	Mean thickness (m)	Est. volume (× $10^6 m^3$)
Fairport Harbor				
Area A				
Upper zone	7.3 to 20	57,58,60,63, 64,67,68,69	2.5	82
Lower zone	7.3 to 20	Same cores as upper zone	1.5	52
Area B	7.3 to 13.7	59	1.5	12
				Total 146
Lorain-Vermilion				
	11 to 14.6	87,89,90,91, 92,93,94,97	See Fig. 17	32

2. Fairport Harbor.

a. Bathymetry and Bottom Sediment. An irregular and arcuate bathymetric high up to 5 kilometers wide that extends northwest of Fairport Harbor for about 10 kilometers roughly defines the lake floor expression of the sand deposit (Fig. 13). Specifically, the high consists of up to three poorly defined ridges 2 to 3 meters high that trend in an east-west direction along the eastern part of the deposit and change to a southeast-northwest direction along the western flank of the deposit. Water depths range from about -7.5 meters near the shore to about -20 meters offshore. The lake bottom adjacent to this feature is irregular nearshore and becomes uniform and flat farther offshore where modern fine-grained sediments have been deposited.

The cores show that the sand at the surface of the Fairport Harbor deposit is relatively well sorted and medium grained, and is exposed between trackline fixes 657 to 662, 665 to 675, and 719 to 729 (Fig. 13). Cores 62, 65, and 66 and the seismic profiles (fixes 652 to 657, 675 to 703, and 729 to 748) show that mud borders the sand to the northeast of the deposit; jetted holes 58, 62, and 66 and the seismic profiles (fixes 662 to 665, 704 to 719, and 748 to 761) show that a poorly sorted mixture of silty sand and gravel lies to the southwest of the deposit.

b. Subbottom Sediment and Sand Volumes. The seismic reflection records and vibracores indicate a 2- to 3-kilometer-wide subbottom deposit of sand ranging from about 1 to 7 meters thick is present at Fairport Harbor. The sand is composed largely of quartz grains and rock fragments; the rock fragments are largely shale and make up to 50 percent of the sand (Hartley, 1960). The deposit is divided into two areas on the basis of sand thickness and textural characteristics as seen in the cores (Fig. 14). Area A consists of two zones: the upper zone is well-sorted, medium- to coarse-grained sand, and the lower zone is moderately sorted, silty, fine- to medium-grained sand. This sand, which essentially underlies the ridges, has a mean thickness of 4 meters and a range of 2 to 7 meters. The upper, medium-grained sand zone has a mean thickness of 2.5 meters and a range of 1.5 to 5.0 meters; the lower, finer grained sand zone has a mean thickness of 1.5 meters and a range of 0.5 to 2.5 meters. The volume of the upper zone, based on the mean thickness of 2.5 meters, is about 82 million cubic meters; the volume of the lower zone, based on a mean thickness of 1.5 meters, is about 52 million cubic meters.

The sand in area B, on the southwest flank of area A, is well sorted and fine grained and has a mean thickness of about 1.5 meters. The volume of sand in this area, based on the mean thickness of 1.5 meters, is about 12 million cubic meters.

Hartley (1960) reported considerably larger sand volumes for the Fairport Harbor deposit than have been estimated in this report. He interpreted jetted-hole data to show sand thicknesses on the order of 6 to 13.5 meters and calculated almost 317 million cubic meters of sand in the deposit. However, comparisons between logs of nearby vibracores and jetted holes indicate that sand thicknesses based on jetting are too large, probably because sand cascading down the hole makes the differentiation of sedimentary contacts in finer grained, noncohesive sediments quite difficult.

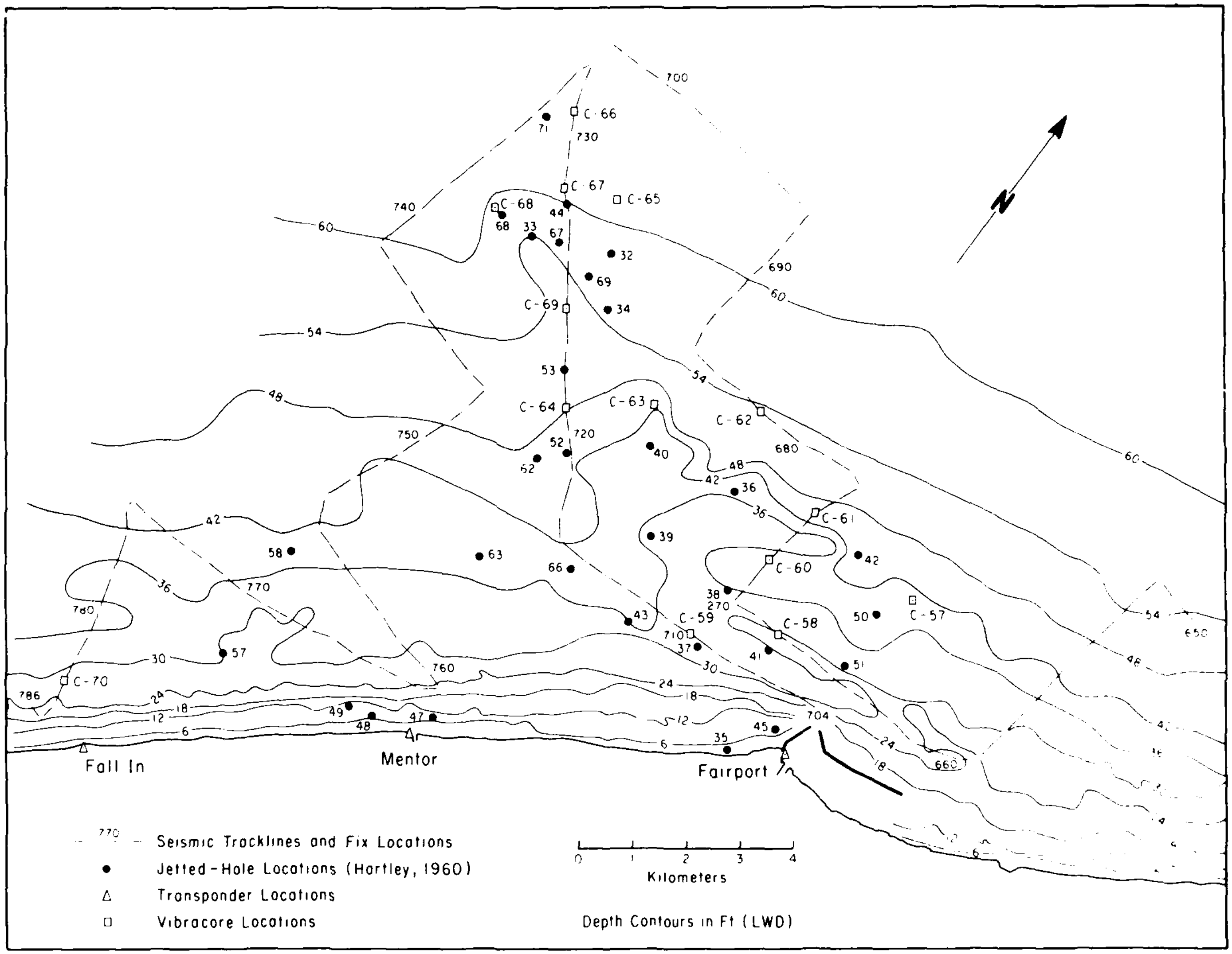


Figure 13. Bathymetry, seismic tracklines, vibracore, and jetted-hole locations of the Fairport Harbor area.

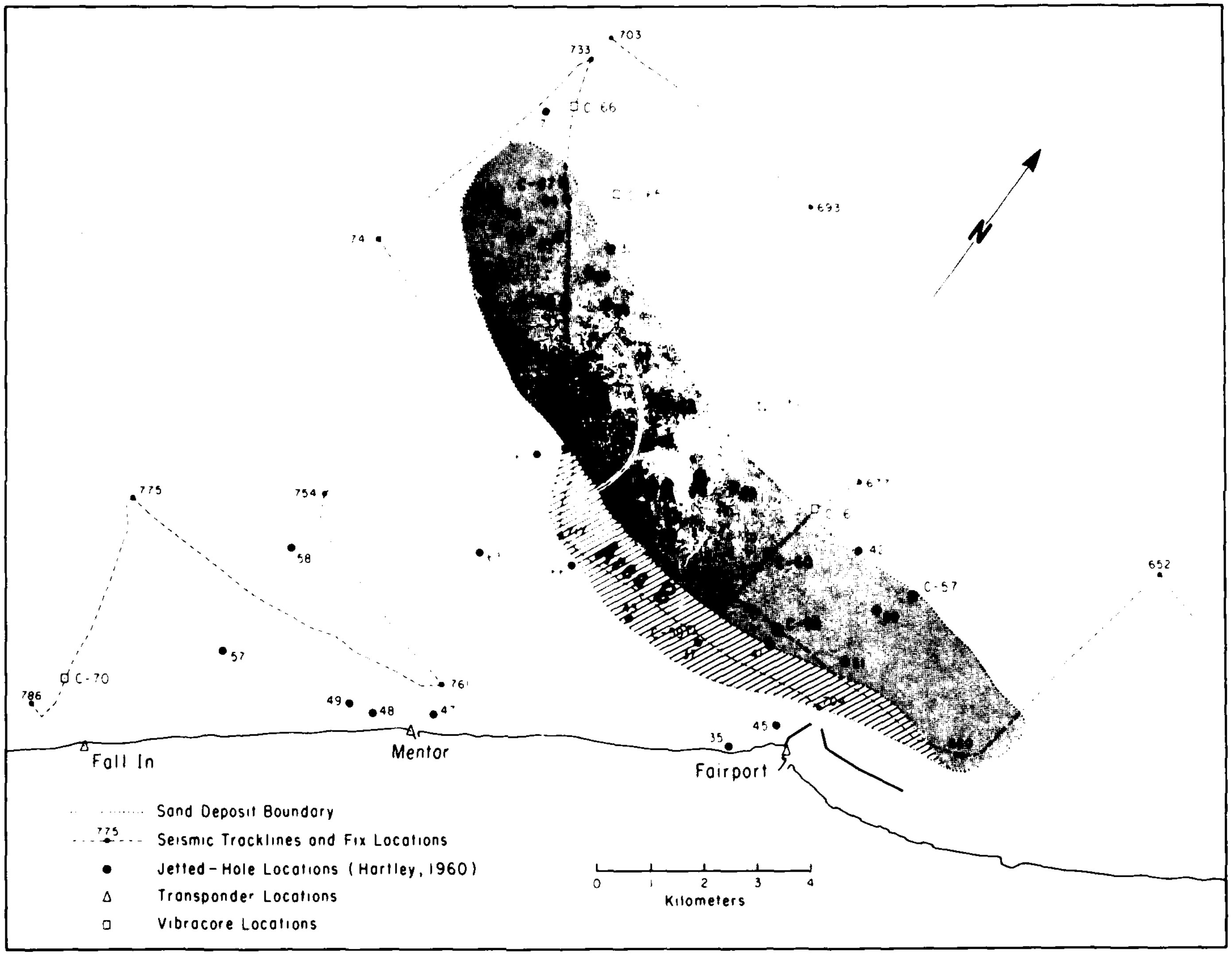


Figure 14. Approximate boundaries of Fairport Harbor sand deposit, areas A and B.

3. Lorain-Vermilion.

a. Bathymetry and Bottom Sediment. The southern part of the Lorain-Vermilion sand deposit forms part of an elongate bathymetric high whose southern limit lies about 9.5 kilometers north of the towns of Lorain and Vermilion, Ohio (Fig. 12). The bathymetric high rises from -14.5 meters and can be divided into two elevated areas, one more prominent within the study area than the other, separated by a shallow trough oriented northwest-southeast (Fig. 15). The prominent high has a "bootlike" shape and is characterized by a 2-kilometer-long ridge on its southern part, similar in morphology to the Presque Isle sand deposit described by Williams and Meisburger (in preparation, 1980). The remainder of this high consists of a more subdued ridge or series of ridges which becomes narrower and more distinct to the north. The other, less prominent high within the study area is the southern end of a broad high which extends northwestward across the lake and joins the Canadian shore at Point Pelee, Ontario.

Surficial sediments on the Lorain-Vermilion bathymetric high are almost exclusively sand and gravel (Fig. 16). The transition from sand to mud is fairly abrupt on the west and south sides of the sand area; in contrast there is a gradual transition from sand to mud on the east side. Till is exposed in places in the northern part of the sand area. Overall, the surficial sand shows a lateral gradation in sediment size from gravel on the west to very fine sand on the east (this same trend was noted by Hartley, 1960). Hartley estimated the composition of the sand using a binocular microscope to be 70 to 80 percent quartz and feldspar. "Shale makes up most of the remainder with fairly abundant heavy minerals. . . . Limestone is common in the sand though it usually comprises less than 10 percent. Shells are locally very abundant and may make up as much as 25 percent of a sand sample." (Hartley, 1960.)

b. Subbottom Sediment and Sand Volumes. The eight cores taken in this area contain well-sorted, fine to coarse sand ranging in thickness from 0.8 to 4 meters. Sand overlies till on the bathymetric high, but caps finer postglacial sediments in the surrounding areas. The sand on the eastern flank of the high has a higher content of silt and clay. Southwest from the high the sand increases in thickness to where the thickest sand accumulation (4 meters) is found in core 90 (Fig. 16). This part of the deposit consists of medium to coarse sand with gravel overlying muddy sand which in turn overlies a clayey silt. To the west of the bathymetric high the contact with the modern lacustrine mud is sharp; cores 95 and 96 contain several meters of mud overlying a gravelly clay till. The sequence of mud over till is also common south and east of the deposit, with the exception of cores 84 and 86 which contain about 3 and 0.5 meters, respectively, of muddy fine to medium sand over a till surface. The extent of the deposit defined by cores 84 and 86 is not well known because of limited data; the sand may represent a minor, localized deposit derived from erosion of the main sand ridge.

Sand volumes were computed for the thickest part of the sand deposit associated with the boot-shaped high using the areas and thicknesses of sand shown on the isopach map (Fig. 17). (The "lag" isopach line is taken to be a "0" thickness of sand for computation of volume, but in reality sand does exist outside this line; see Fig. 16.) The volume calculated is about 32 million cubic meters. Hartley's (1960) isopach map of the same area gives a similar volume, assuming his 1-foot contour correlates with the lag contour in this report.

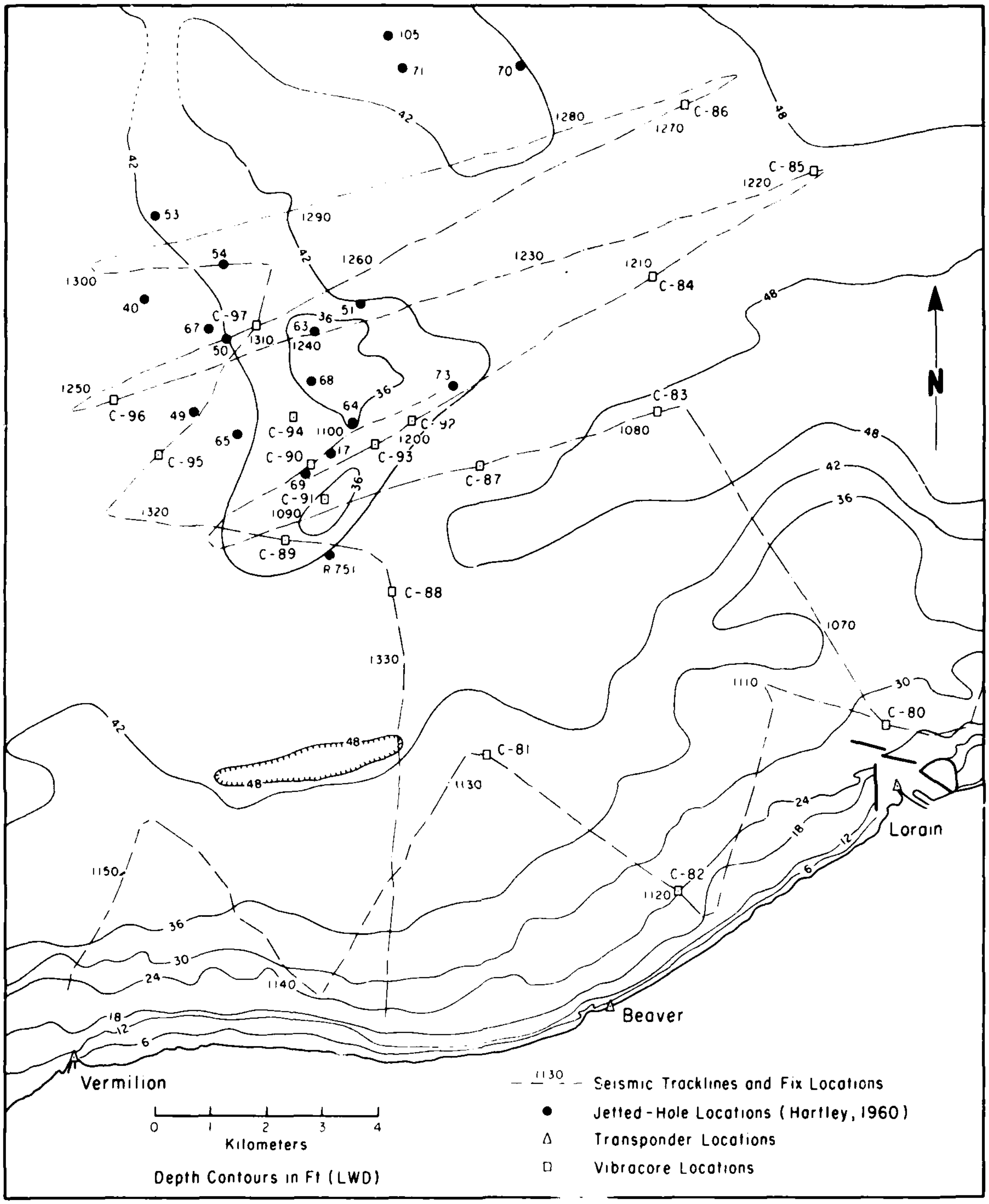


Figure 15. Bathymetry, seismic tracklines, vibracore, and jetted-hole locations at the Lorain-Vermilion area.

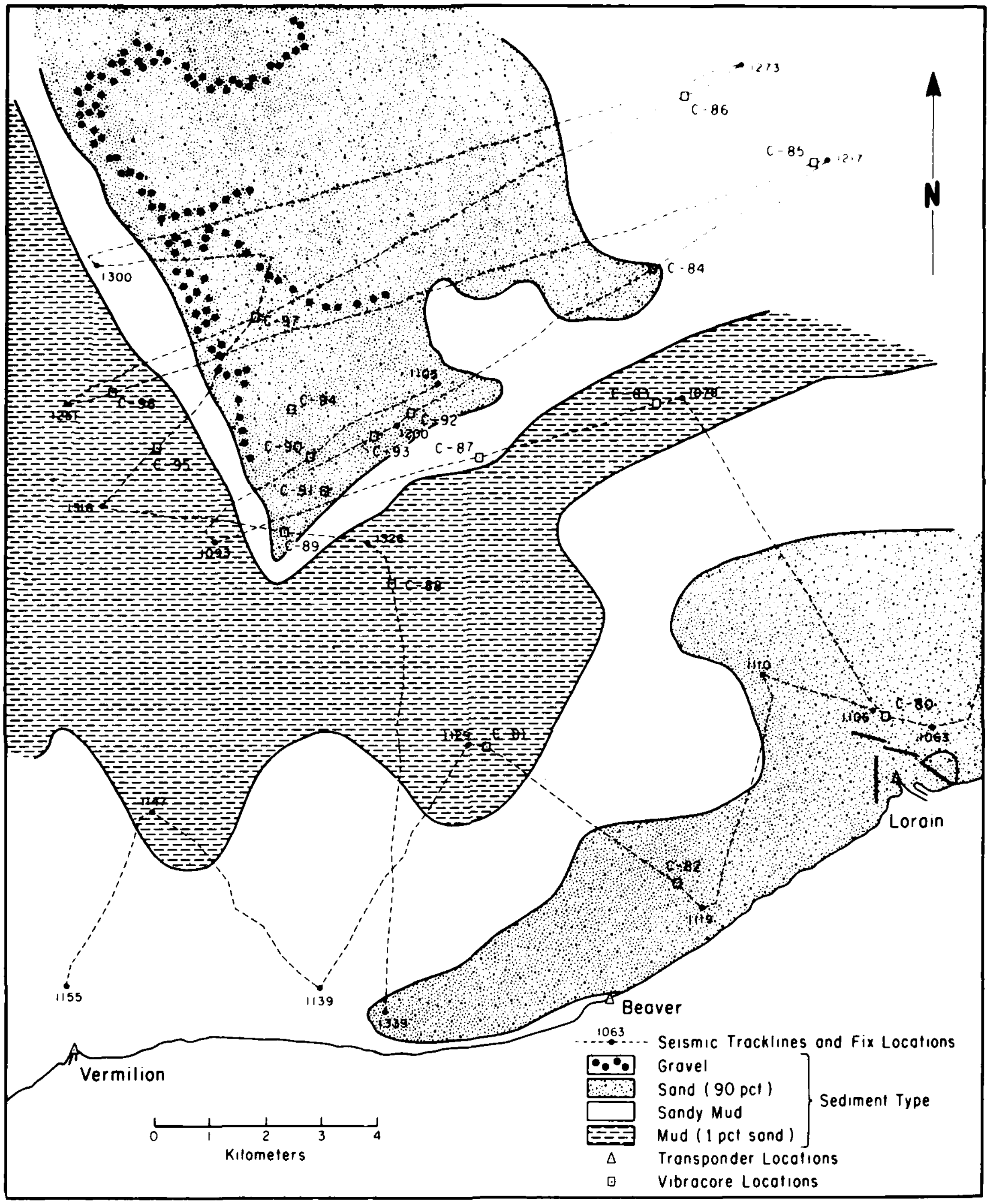


Figure 16. Surface sediment in the Lorain-Vermilion area (modified from Hartley, 1960).

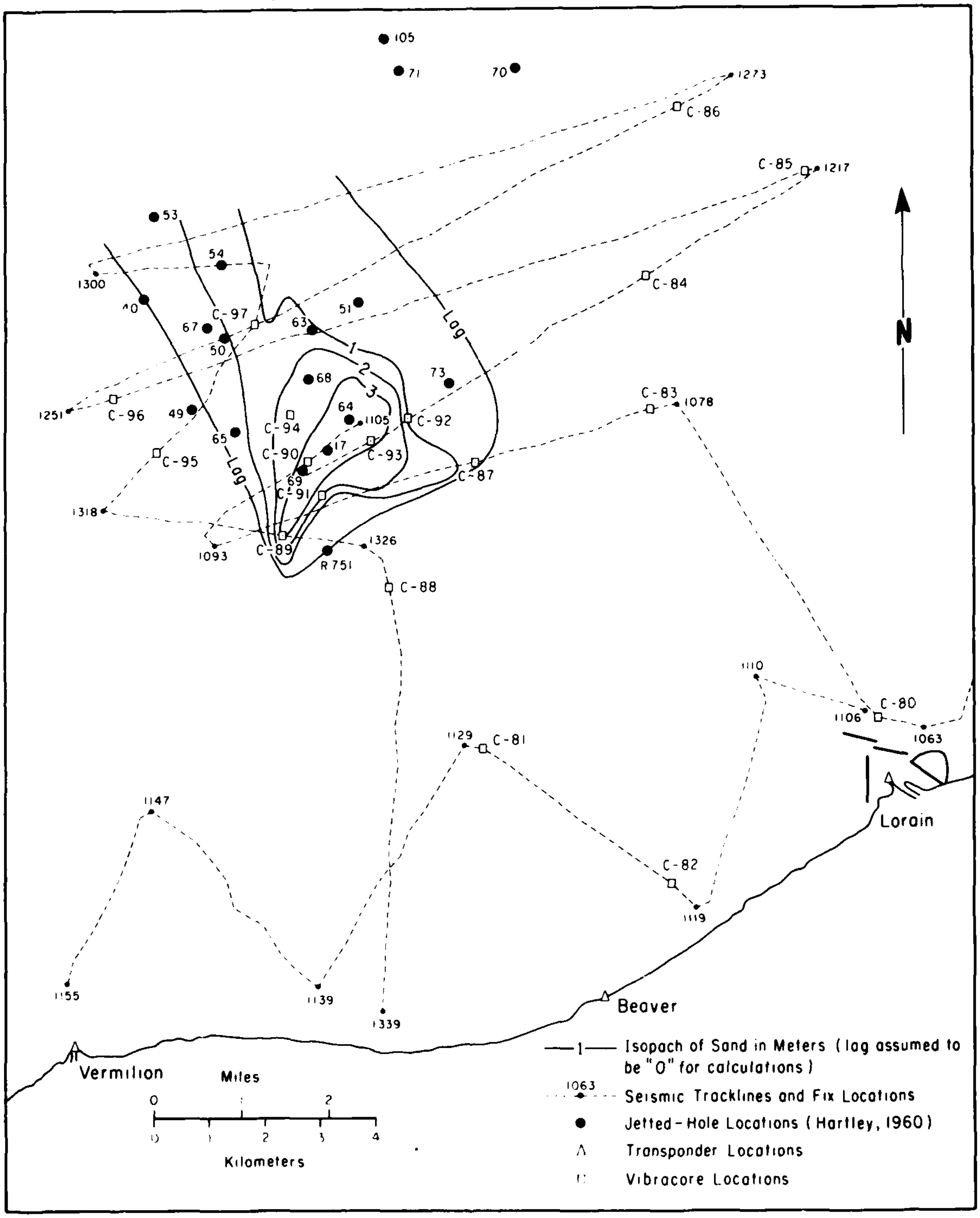


Figure 17. Sand isopach of Lorain-Vermilion sand deposit.

This similarity of volume is in contrast to what was found at the Fairport Harbor deposit. The explanation appears to be that because of the thin nature of this deposit, and because sand rests directly on cohesive till in a large part of the area (see cores 97 and 92), the jetted-hole data give a more reliable estimate of sand thickness in the Lorain-Vermilion area than in the Fairport Harbor area. Hartley (1960) calculated that about 102 million cubic meters of sand was present in the entire Lorain-Vermilion deposit within the United States. This figure seems reasonable since plate 19 in his study shows sand in thicknesses of 0.3 to 1.5 meters on the bathymetric ridge extending to the U.S.-Canada border. Additional cores and seismic profiles would be necessary to substantiate his jetted-hole data in this area.

4. Cedar Point.

a. Bathymetry and Bottom Sediment. The Cedar Point sand deposit, which includes the Bay Point spit, is at the mouth of Sandusky Bay (Fig. 18). Generally, the bottom slopes gently lakeward, except for a bathymetric high made up of rock (dredged from the harbor channel) that lies about 1.5 kilometers north of transponder location "CG."

Surficial deposits consist of fine and very fine sand that grade offshore through muddy sands to lacustrine muds (Fig. 19). The surface sand averages 93 to 94 percent quartz and feldspar, 3 to 4 percent shale, and 3 to 4 percent heavy minerals with only trace amounts of shell and limestone fragments (Hartley, 1960).

b. Subbottom Sediment and Sand Volumes. Since the seismic records over the area show little acoustic penetration, an interpretation of the subbottom is impossible. The lack of penetration is probably due to the dense fine-grained nature of the sediment. Only one of the seven cores taken had an appreciable quantity of sand; core 101 had 5.6 meters of fine and medium sand.

The jetted-hole data from Hartley (1960) and Herdendorf and Braidech (1972) suggest that thick accumulations of very fine and fine sand are present near vibracore hole 101; they concluded that fine sand overlies a coarser sand and gravel which overlies compacted lacustrine clays. Hartley (1960) states that bedrock is from about 13 to 19 meters below lake level in this area.

The poor seismic records and limited vibracore coverage prevent an accurate sand volume calculation for this deposit. Moreover, it is likely that large volumes of sand are present on the shoal platform southeast of the Cedar Point jetty (the entire Cedar Point-Bay Point sand deposit was probably built up by longshore transport from the east) and because the area is accretional some sand could be removed without causing erosion on the Cedar Point-Bay Point shore. Additional information on the longshore transport regime would be necessary, however, before this proposal could be considered. Furthermore, even though the Cedar Point-Bay Point deposit may have a large quantity of sand, the sand is fine grained which would probably limit its use for beach nourishment.

5. Maumee Bay.

Since the seismic records of this area show little acoustic penetration, an interpretation of the subbottom would only be marginal; this coupled with a lack

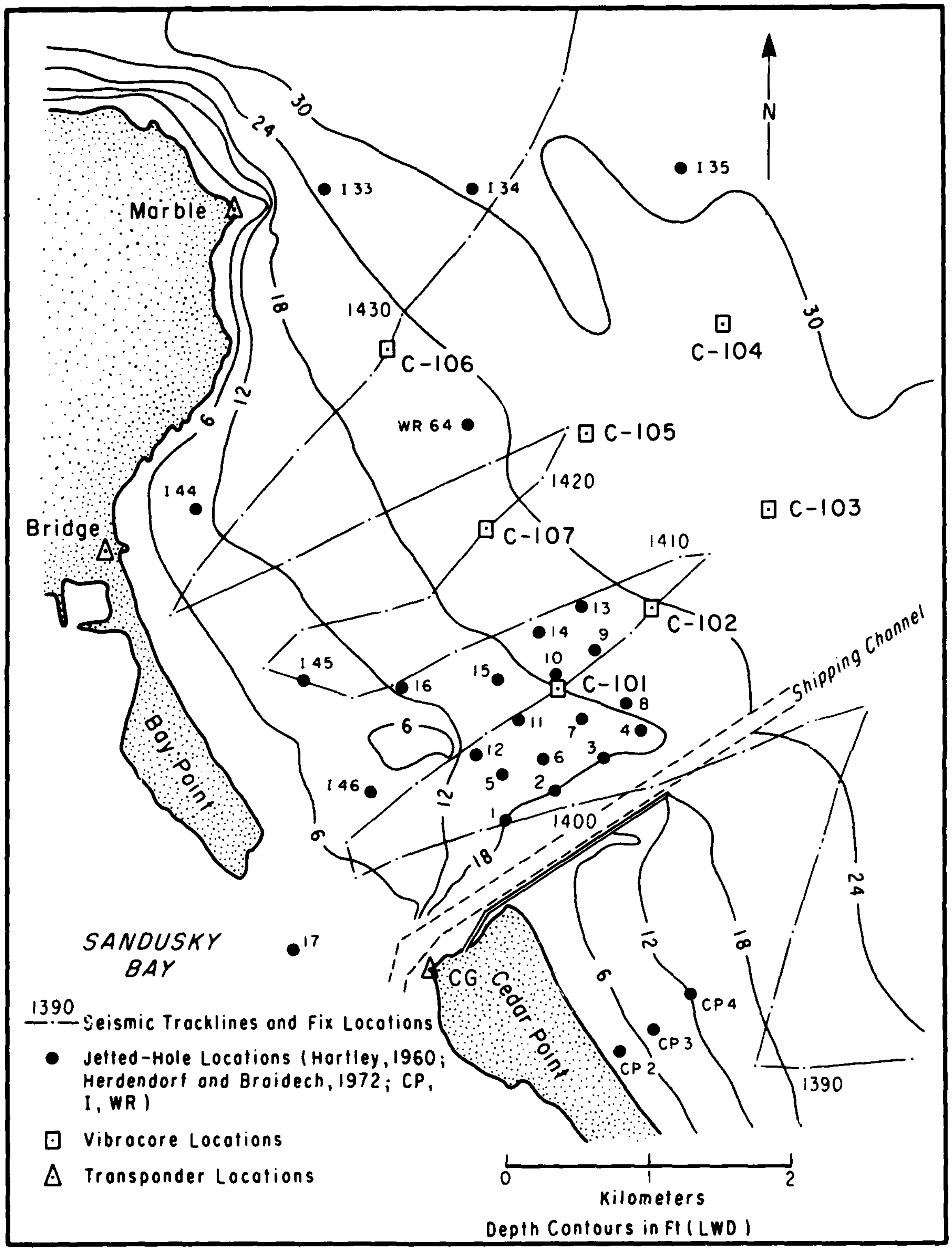


Figure 18. Bathymetry, seismic tracklines, vibracore, and jetted-hole locations of the Cedar Point area.

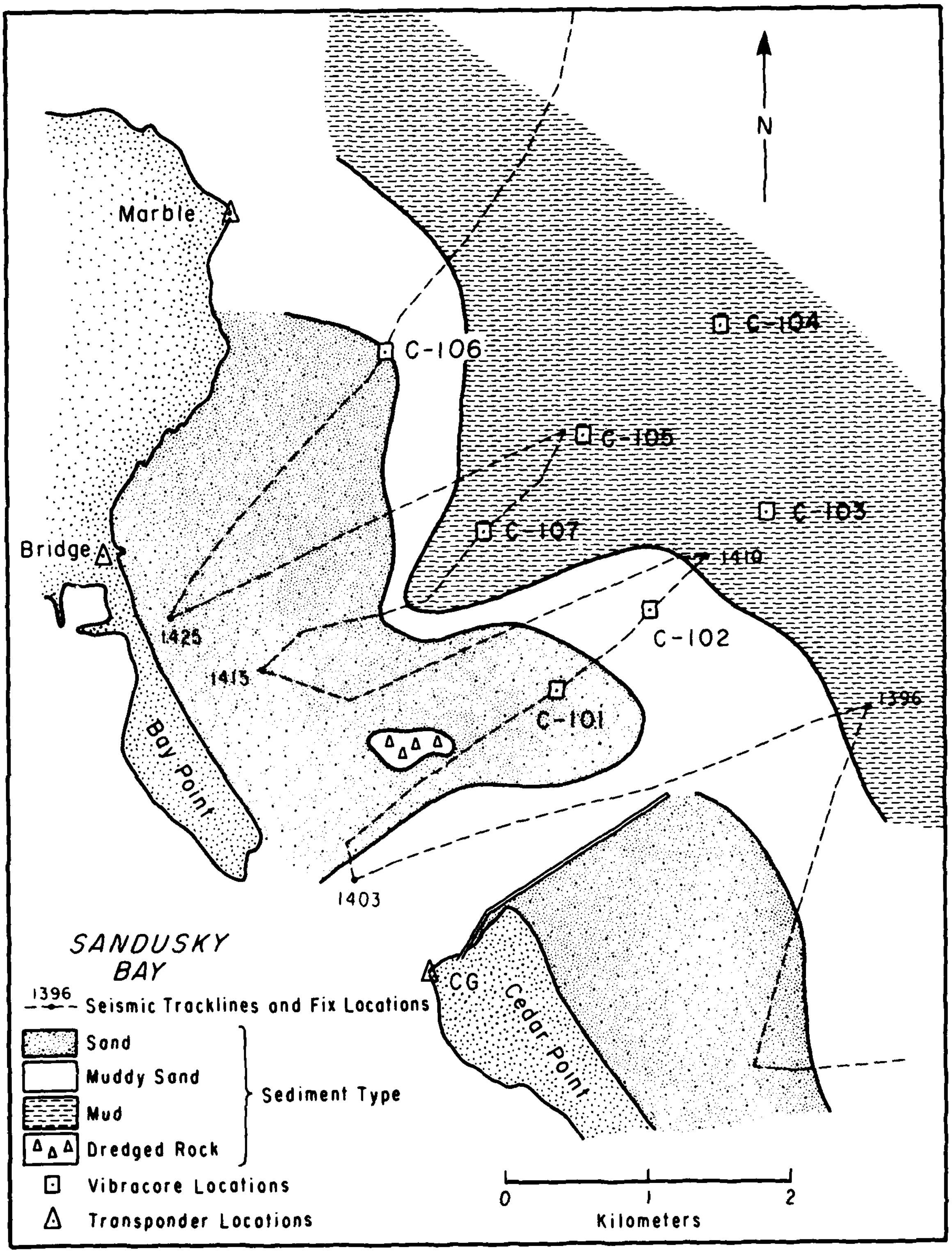


Figure 19. Surface sediment in the Cedar Point area (modified from Hartley, 1960).

of vibracore data precludes any interpretation from this survey. However, because the area probably contains a sizable quantity of sand, the following data on bathymetry and bottom sediment are included from Hartley's (1960) study.

a. Bathymetry and Bottom Sediment. Maumee Bay is very shallow and bounded by low clay shores and marshland. The maximum natural water depth is only 10 feet below LWD. The shipping channel is dredged and maintained at 25 feet below LWD.

The sand and gravel deposit is a low ridge widening from less than 0.5 mile at Little Cedar Point to more than 2 miles at its northern end near Turtle Island. On the western and northern sides the deposit terminates abruptly with a rather sharp sand-mud boundary. Eastward the change to mud is indefinite and there is no mappable boundary.

The western and northern sides of the deposit are also relatively steep. The higher surfaces of the deposit rise to a maximum of about 7 feet above the general bottom level. Turtle Island, actually a part of the deposit, rises a few feet above water level.

The majority of the sand is fine grained. The remainder is coarse sand and gravel; there is a conspicious lack of medium-grained sand in the deposit.

Quartz and feldspar make up an average of 85 to 90 percent of the grains in the fine sand sizes, 50 percent of the medium sand particles, and little or none in coarse sizes. Limestone and shale particles, increase as do crystalline rock particles, as the grain size increases.

b. Subbottom Sediment and Sand Volumes. The unconsolidated surface deposits in Maumee Bay overlie firm clay which is of two types, lacustrine clay deposited in the present lake and glacial clay till containing many small rock fragments. It appears that the surface of the till is undulating and that the depressions have been filled with lake clays and silts. Hartley (1960) estimated that there is about 49 million cubic meters of sediment above the clay surface within the deposit area.

The poor seismic records and lack of vibracore coverage preclude an accurate recalculation of sand volume in this deposit. Moreover, because the overall nature of the deposit is similar to that of the Cedar Point area the fine-grained nature of the sand may limit its use for beach nourishment.

IV. SUMMARY AND RECOMMENDATIONS

The primary objective of this study is to provide a general evaluation of the Lake Erie shallow subbottom between Conneaut and Toledo, Ohio, for potential sand and gravel deposits suitable for beach restoration and maintenance programs. Primary survey data consist of 690 kilometers of high-resolution seismic reflection profiles taken between Conneaut and Toledo, and 58 vibracores with a maximum length of 6.1 meters taken between Conneaut and Marblehead. About 25 percent of Ohio's open lake part of Lake Erie was covered in the seismic reflection survey. Water depths in the study area range from about 4 to 21 meters.

Four sites are identified as containing possible borrow material but only two (Fairport Harbor and Lorain-Vermilion) are judged to be of high potential for beach nourishment; the four sites were described initially by Hartley (1960). No new sizable sand deposits were found although much of the subbottom was unmapped before the CERC-ODGS survey.

The major area of the Fairport Harbor sand deposit contains an estimated 134 million cubic meters of fine- to medium-grained quartz and shale fragment sand based on an average thickness of 4 meters; an adjacent area contains an estimated 12 million cubic meters of similar sand based on an average thickness of about 1.5 meters.

The part of the Lorain-Vermilion deposit which was resurveyed in this study contains an estimated 32 million cubic meters of a fine-grained quartz and feldspar rich sand with gravel, based on calculations from the isopach map in Figure 17. However, significant additional sand deposits are shown by the Beach Erosion Board (1952) and Hartley (1960) to be associated with a ridge, north of the surveyed area, that crosses Lake Erie to Point Pelee, Ontario.

Both the Cedar Point and Maumee Bay deposits are considered low potential for beach nourishment because of their fine grain size.

At present, sand is commercially dredged from the Fairport Harbor, Lorain-Vermilion, and Maumee Bay deposits. Sand from the Lorain-Vermilion deposit was used by the U.S. Army Corps of Engineers to nourish the beach at Lakewood Park, Lorain.

If a significant volume of any of the deposits is needed for a project, it is recommended that additional cores be taken to provide more detailed information on the three-dimensional framework of the deposit as well as to provide additional textural data for proper design of the beach-fill material.

LITERATURE CITED

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, "Seismic Stratigraphy - Application to Hydrocarbon Exploration," C.E. Payton, ed., Memoir 26, Tulsa, Okla., 1977.

BARNS, B., et al., "Geologic Prediction: Developing Tools and Techniques for the Geophysical Identification and Classification of Sea Floor Sediments," TR ERL 224-MMTC-2, National Oceanic and Atmospheric Administration, Rockville, Md., 1972.

BEACH EROSION BOARD, "Ohio Shoreline of Lake Erie, Sandusky to Vermilion, Ohio," H.Doc. 32, 83d Cong., 1st sess., U.S. Army, Corps of Engineers, Washington, D.C., July 1952.

BENSON, D.J., "Lake Erie Shore Erosion and Flooding, Lucas County, Ohio," Investigation Report 107, Ohio Division Geological Survey, Columbus, Ohio, 1978.

CARTER, C.H., "Lake Erie Shore Erosion, Lake County, Ohio: Setting, Processes and Recession from 1876 to 1973," Investigation Report 99, Ohio Division Geological Survey, Columbus, Ohio, 1976, p. 115.

CARTER, C.H., et al., "Regional Geology of the Southern Lake Erie Bottom Between Conneaut and Marblehead, Ohio - A Seismic Reflection and Vibracore Study," U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va. (in preparation, 1980).

DAMES AND MOORE, "Airport Feasibility Study - Lake Bottom Geotechnical and Geophysical Studies," Reports 5-1 and 5-2, Mar. 1974.

DUANE, D.B., "Sand Deposits on the Continental Shelf, A Presently Exploitable Resource," *Proceedings of the Marine Technology Society Regional Meeting*, 1968, pp. 289-297.

EWING, J.I., "Elementary Theory of Seismic Refraction and Reflection Measurements," *The Earth Beneath the Sea*, Interscience Publication, New York, Ch. 1, Vol. 3, 1963, pp. 3-19.

FOLK, R.L., *Petrology of Sedimentary Rocks*, Hemphill Publishing Co., Austin, Tex., 1974.

GUY, H.P., "Laboratory Theory and Methods for Sediment Analysis," Book 5, Ch. C1, *Techniques of Water Resources Investigations of the United States Geological Survey*, U.S. Government Printing Office, Washington, D.C., 1969.

HARTLEY, R.P., "Bottom Deposits in Ohio Waters of Central Lake Erie," Technical Report 6, Ohio Division of Shore Erosion, Columbus, Ohio, 1961.

HARTLEY, R.P., "Sand Dredging Areas in Lake Erie," Technical Report 5, Ohio Division of Shore Erosion, Columbus, Ohio, 79 pp.

HERDENDORF, C.E., and BRAIDECH, L.L., "Physical Characteristics of the Reef Area of Western Lake Erie," Investigation Report 82, Ohio Department of Natural Resources, Columbus, Ohio, 1972.

MEISBURGER, E.P., WILLIAMS, S.J., and PRINS, D.A., "Sand Resources of Southeastern Lake Michigan," MR 79-3, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., July 1979.

MOORE, D.G., and PALMER, H.P., "Offshore Seismic Refraction and Reflection Measurements," *The Earth Beneath the Sea*, Interscience Publication, New York, Ch. 1, Vol. 3, 1967, pp. 3-19.

MORGAN, N.A., "Geophysical Studies in Lake Erie by Shallow Marine Seismic Methods," unpublished Ph.D. Dissertation, University of Toronto, Toronto, Canada, 1964.

RAMSEY, M.D., and GALVIN, C.J., Jr., "Size Analysis of Sand Samples from Southern New Jersey Beaches," MR 77-3, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Mar. 1977.

TIREY, G.B., "Recent Trends in Underwater Soil Sampling Methods," Special Technical Publication 501, American Society for Testing and Materials, Philadelphia, Pa., 1972.

U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols. I, II, and III, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, 1,262 pp.

U.S. INTER-AGENCY COMMITTEE ON WATER RESOURCES, "Operators Manual on Visual-Accumulation-Tube Method for Sedimentation Analysis of Sands," Report K, *A Study of Methods Used in Measurement and Analysis of Sediment Loads in Streams*, Subcommittee on Sedimentation, 1958.

VERBER, J.L., "Bottom Deposits of Western Lake Erie," Technical Report 4, Ohio Department of Natural Resources, Columbus, Ohio., 1957.

WALL, R.E., "A Sub-Bottom Reflection Survey in the Central Basin of Lake Erie," *Geological Society of America Bulletin*, Vol. 79, 1968, pp. 91-106.

WILLIAMS, S.J., PRINS, D.A., and MEISBURGER, E.P., "Sediment Distribution, Sand Resources and Geologic Character of the Inner Continental Shelf off Galveston County, Texas," MR 79-4, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., July 1979.

WILLIAMS, S.J., and MEISBURGER, E.P., "Sand and Gravel Resources and Geologic Character of Central Lake Erie-Conneaut, Ohio, to Erie Pennsylvania," U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va. (in preparation, 1980).

APPENDIX A

CORE SEDIMENT DESCRIPTIONS

This appendix contains core sediment descriptions, based on both megascopic and microscopic examinations. Color is based on damp samples as referred to the Munsell color system (Munsell Soil Color Charts, 1954 ed., Munsell Color Co., Inc., Baltimore, Md.); grain size is based on the Wentworth size scale (see Table 1).

The marks on the left side of the stratigraphic log are placed at the midpoints of sampled intervals used for size analysis. The type of analysis is designated by the following codes (size data are tabulated in App. B):

R - Rapid Sand Analyzer (RSA)

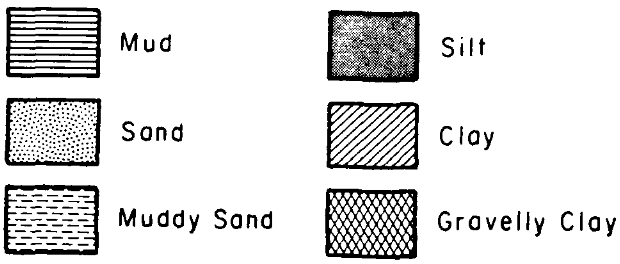
S - Sieve analysis

V - Visual Accumulation Tube (VAT)

P - Pipet analysis

B - Bottom of core

Sediments are grouped into the following six basic categories for logging (minimum unit thickness shown is 20 centimeters):



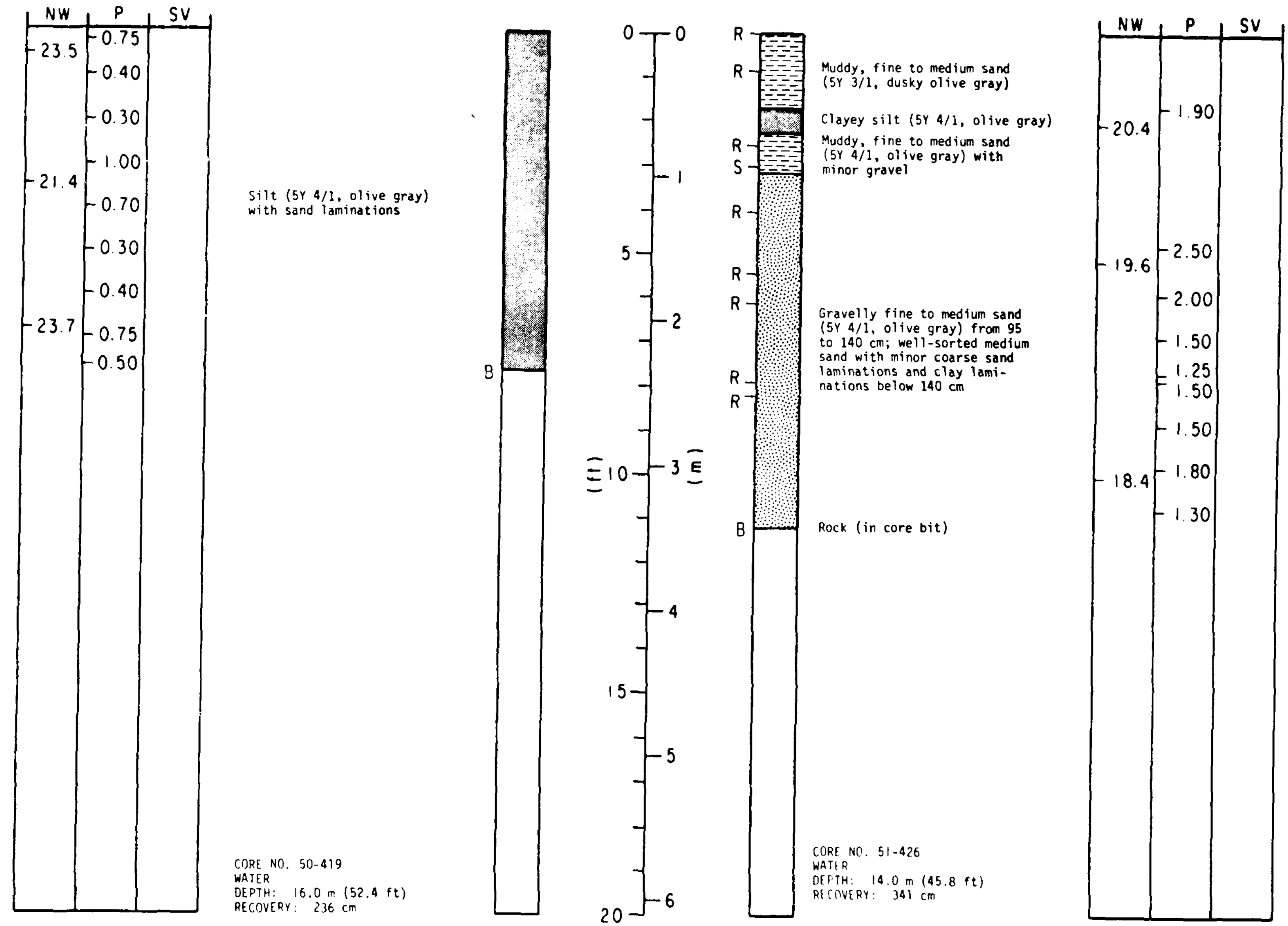
Column descriptions for core sediments are:

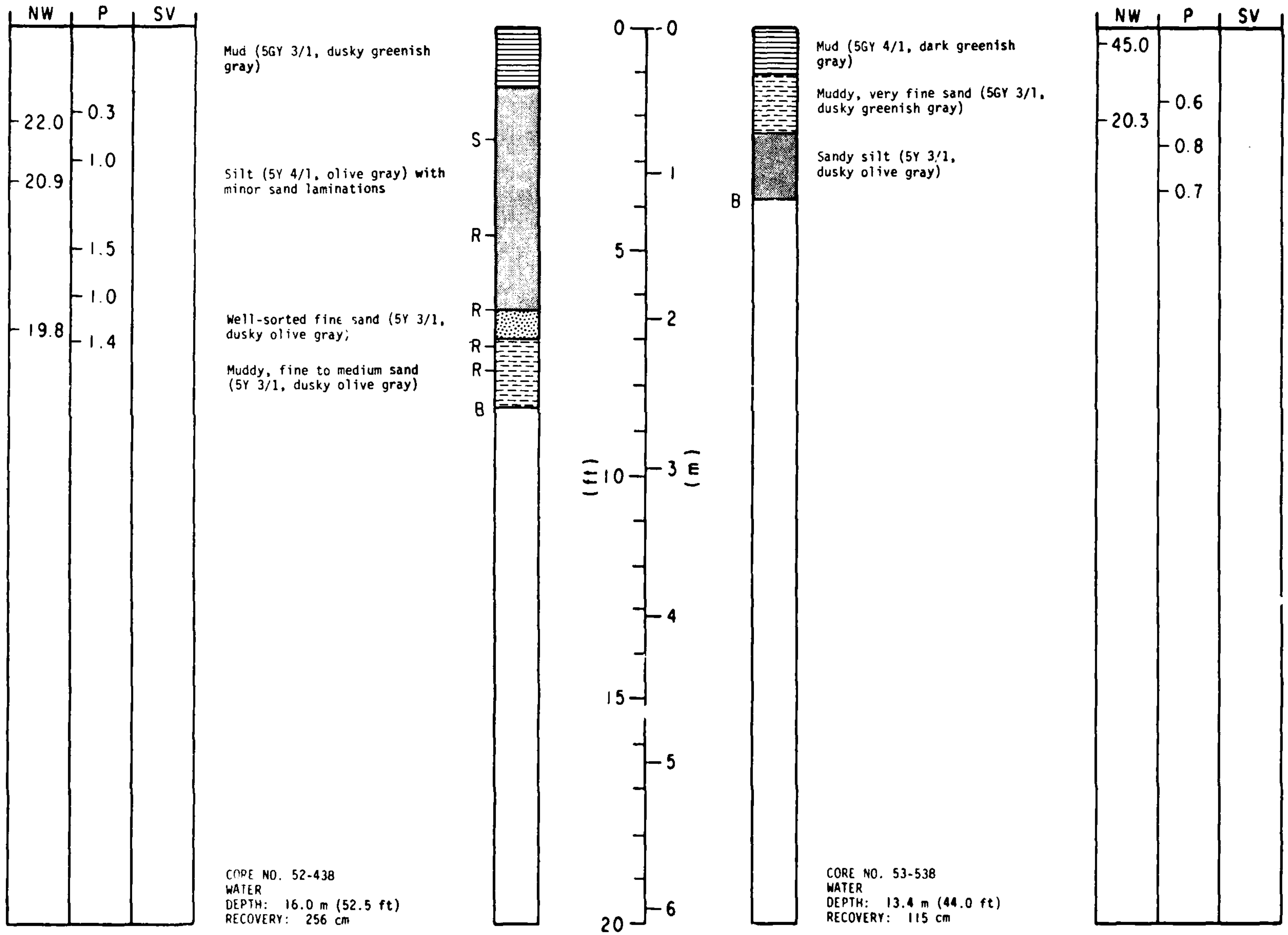
NW = midpoint of sampled sediment used for natural water determinations (interval usually 10 centimeters long); number is: weight of wet sediment minus weight of dry sediment divided by weight of wet sediment times 100.

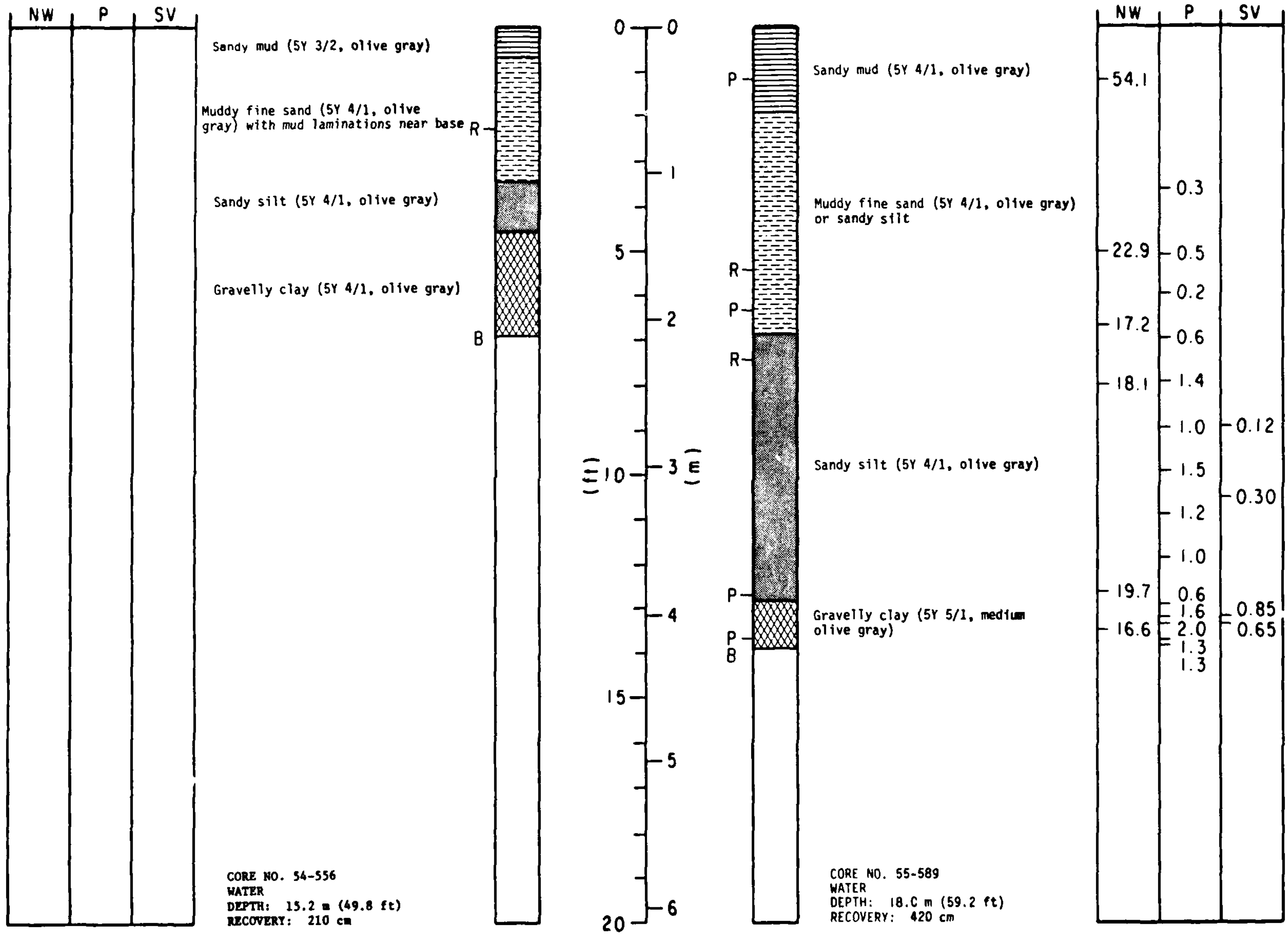
P = penetrometer measurement (in tons per square inch or kilograms per square centimeter).

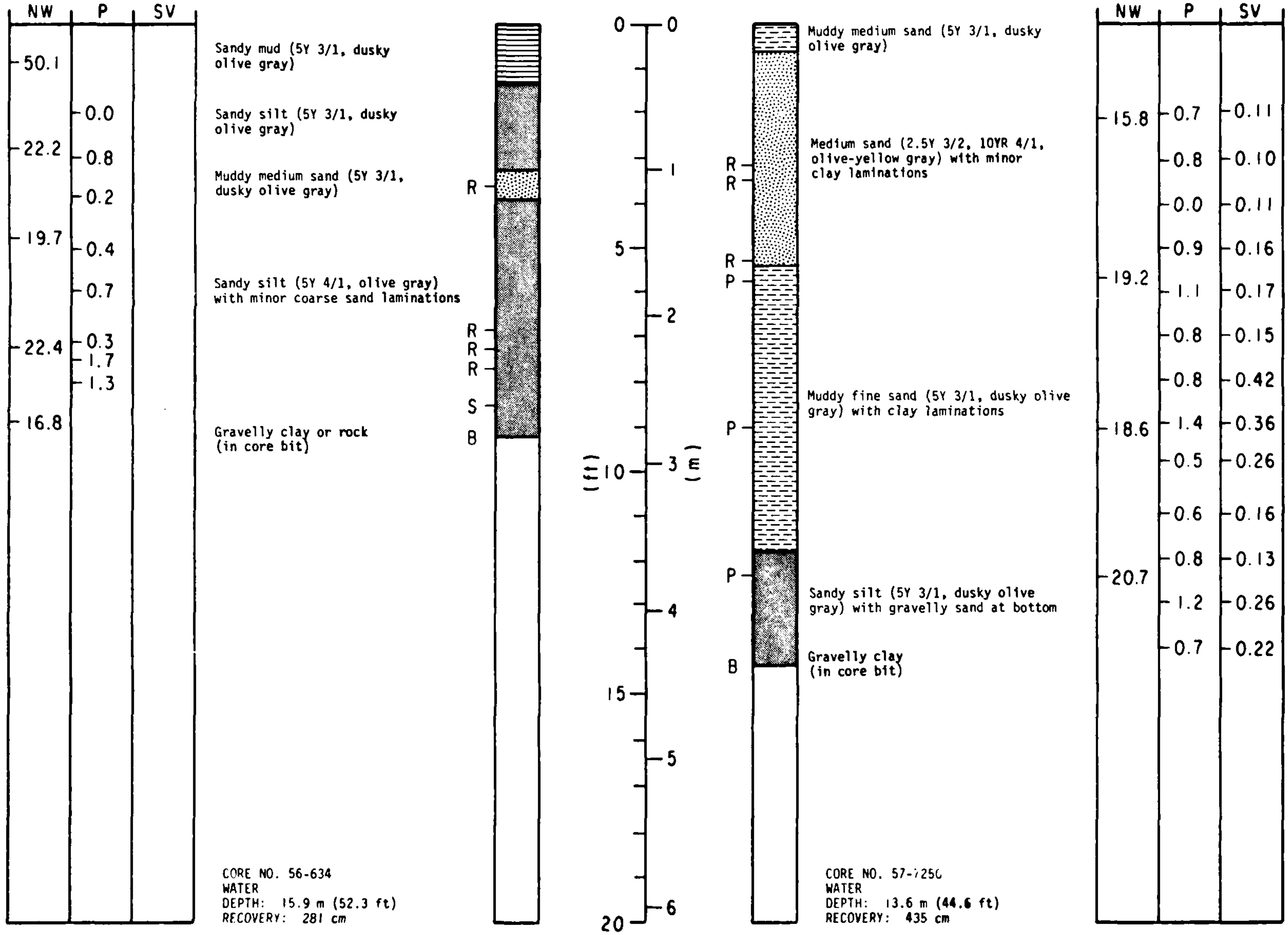
SV = shear vane measurement (in tons per square inch or kilograms per square centimeter); PF = plastic flow.

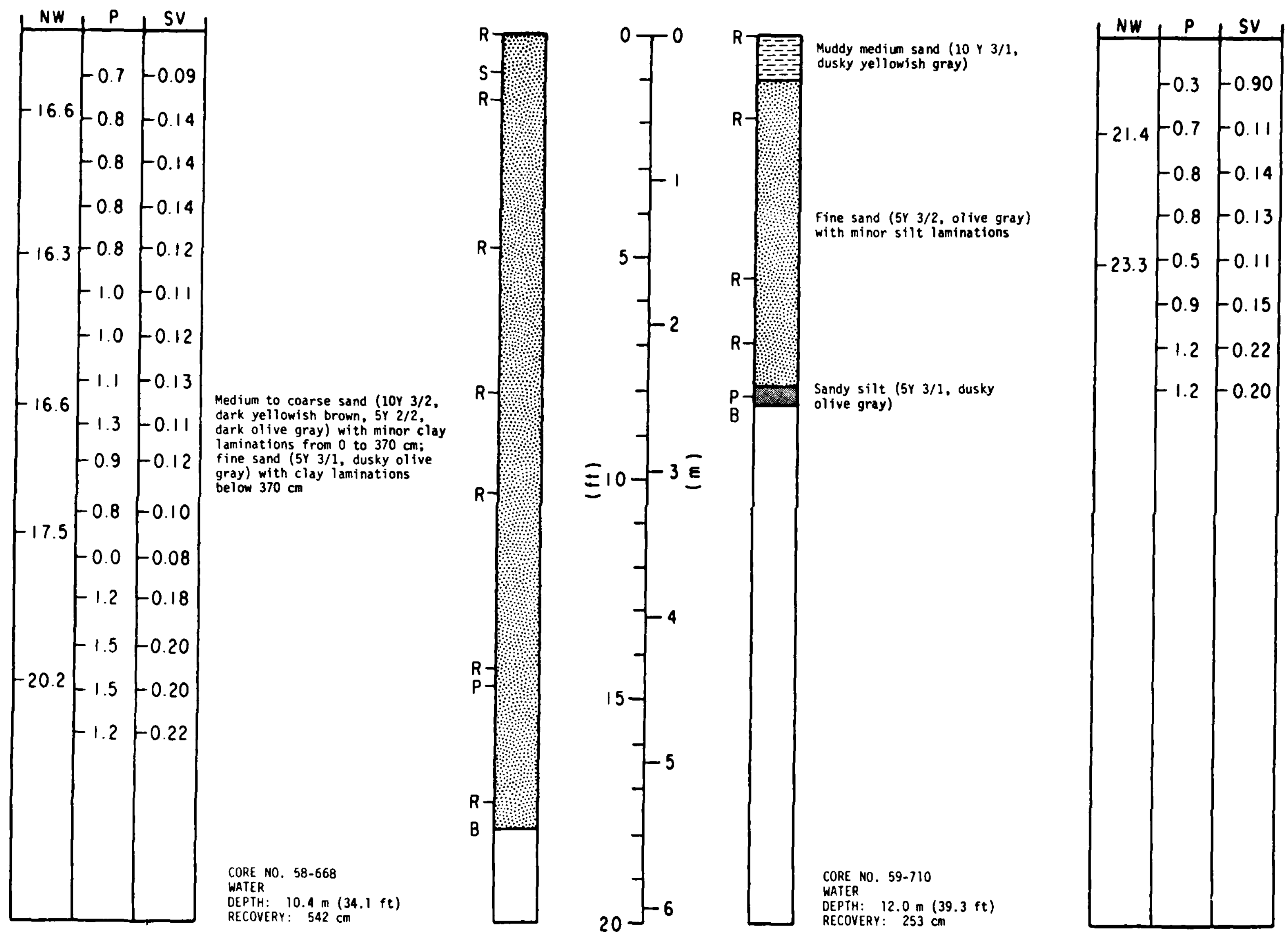
Water depths are the surveyed water depths; these depths were about 1 meter above low water datum (LWD) for Lake Erie.


NW
P
SV
23.5
21.4
23.7
0.75
0.40
0.30
1.00
0.70
0.30
0.40
0.75
0.50
Silt (5Y 4/1, olive gray) with sand laminations
CORE NO. 50-419
WATER
DEPTH: 16.0 m (52.4 ft)
RECOVERY: 236 cm
B
(ft)
0
5
10
15
20
(m)
0
1
2
3
4
5
6
Muddy, fine to medium sand (5Y 3/1, dusky olive gray)
Clayey silt (5Y 4/1, olive gray)
Muddy, fine to medium sand (5Y 4/1, olive gray) with minor gravel
Gravelly fine to medium sand (5Y 4/1, olive gray) from 95 to 140 cm; well-sorted medium sand with minor coarse sand laminations and clay laminations below 140 cm
Rock (in core bit)
CORE NO. 51-426
WATER
DEPTH: 14.0 m (45.8 ft)
RECOVERY: 341 cm
20.4
19.6
18.4
1.90
2.50
2.00
1.50
1.25
1.50
1.50
1.80
1.30

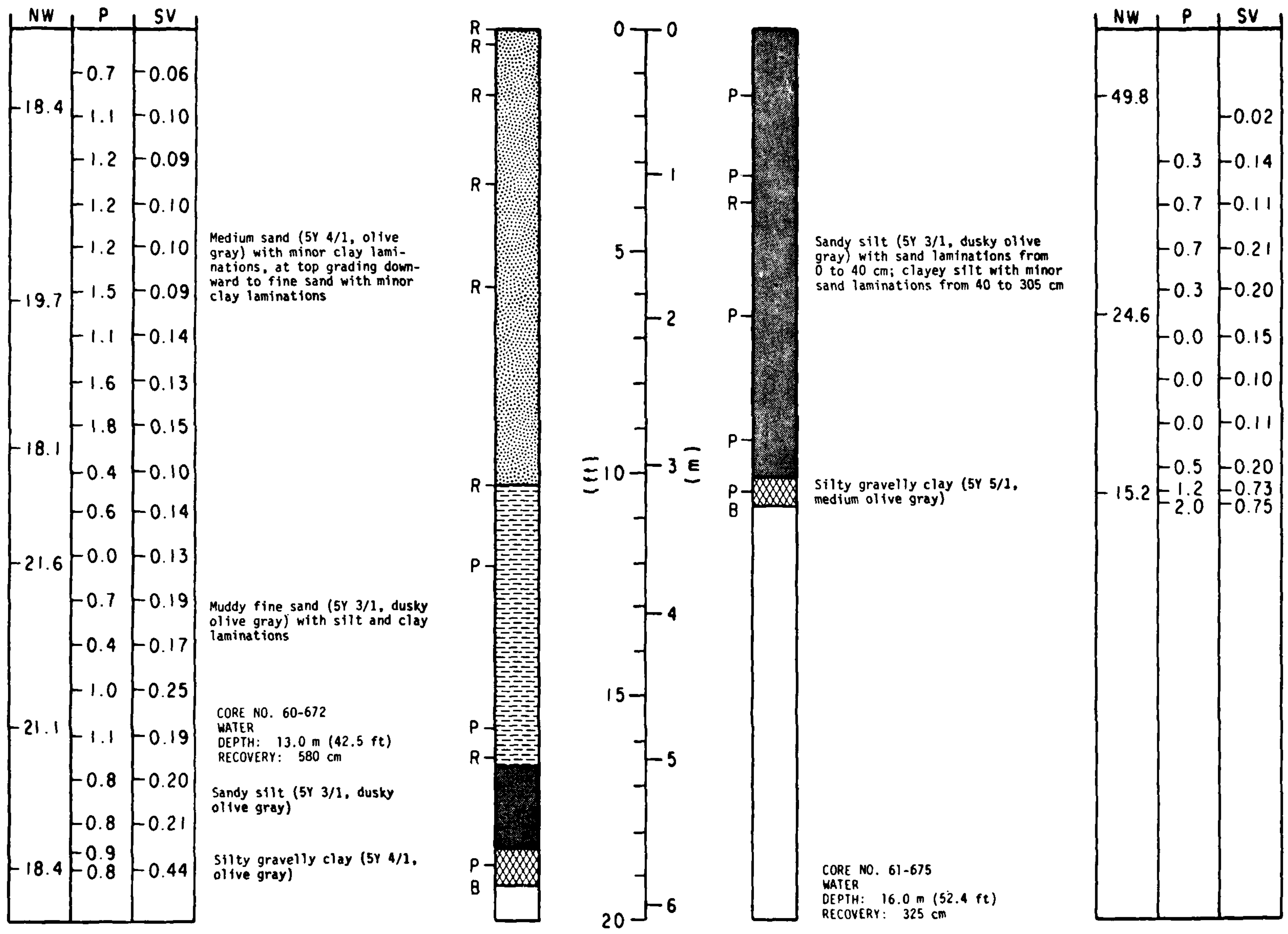

NW
P
SV
22.0
20.9
19.8
0.3
1.0
1.5
1.0
1.4
Mud (5GY 3/1, dusky greenish gray)
Silt (5Y 4/1, olive gray) with minor sand laminations
Well-sorted fine sand (5Y 3/1, dusky olive gray)
Muddy, fine to medium sand (5Y 3/1, dusky olive gray)
S
R
R
R
R
B
CORE NO. 52-438
WATER DEPTH: 16.0 m (52.5 ft)
RECOVERY: 256 cm
(ft)
0
5
10
15
20
(m)
0
1
2
3
4
5
6
Mud (5GY 4/1, dark greenish gray)
Muddy, very fine sand (5GY 3/1, dusky greenish gray)
Sandy silt (5Y 3/1, dusky olive gray)
B
CORE NO. 53-538
WATER DEPTH: 13.4 m (44.0 ft)
RECOVERY: 115 cm
NW
P
SV
45.0
20.3
0.6
0.8
0.7

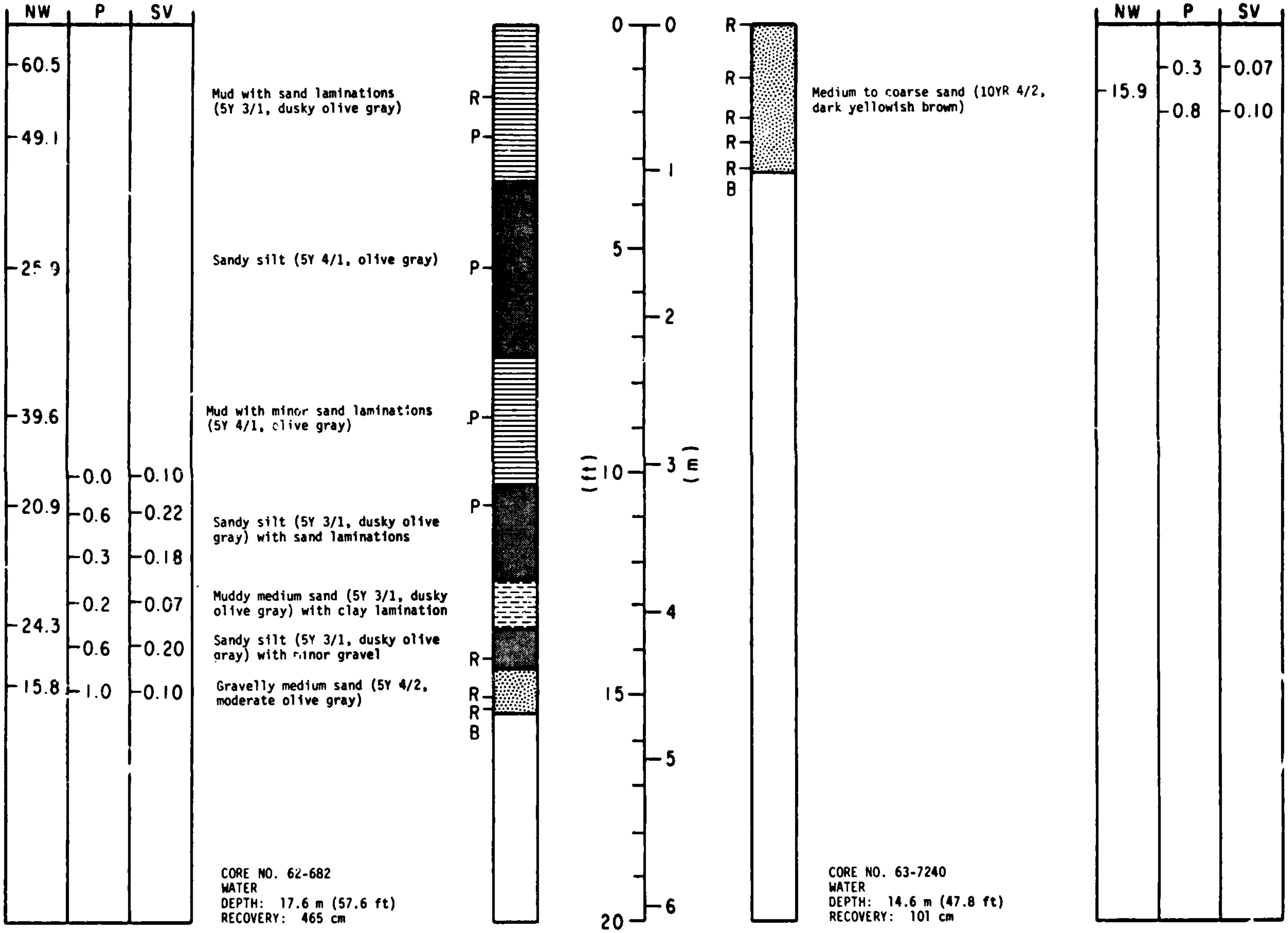

NW
P
SV
Sandy mud (5Y 3/2, olive gray)
Muddy fine sand (5Y 4/1, olive gray) with mud laminations near base
Sandy silt (5Y 4/1, olive gray)
Gravelly clay (5Y 4/1, olive gray)
R
B
CORE NO. 54-556
WATER
DEPTH: 15.2 m (49.8 ft)
RECOVERY: 210 cm
(ft)
0
5
10
15
20
(m)
0
1
2
3
4
5
6
Sandy mud (5Y 4/1, olive gray)
Muddy fine sand (5Y 4/1, olive gray) or sandy silt
Sandy silt (5Y 4/1, olive gray)
Gravelly clay (5Y 5/1, medium olive gray)
P
R
P
R
P
P
B
CORE NO. 55-589
WATER
DEPTH: 18.C m (59.2 ft)
RECOVERY: 420 cm
NW
P
SV
54.1
22.9
17.2
18.1
19.7
16.6
0.3
0.5
0.2
0.6
1.4
1.0
1.5
1.2
1.0
0.6
1.6
2.0
1.3
1.3
0.12
0.30
0.85
0.65

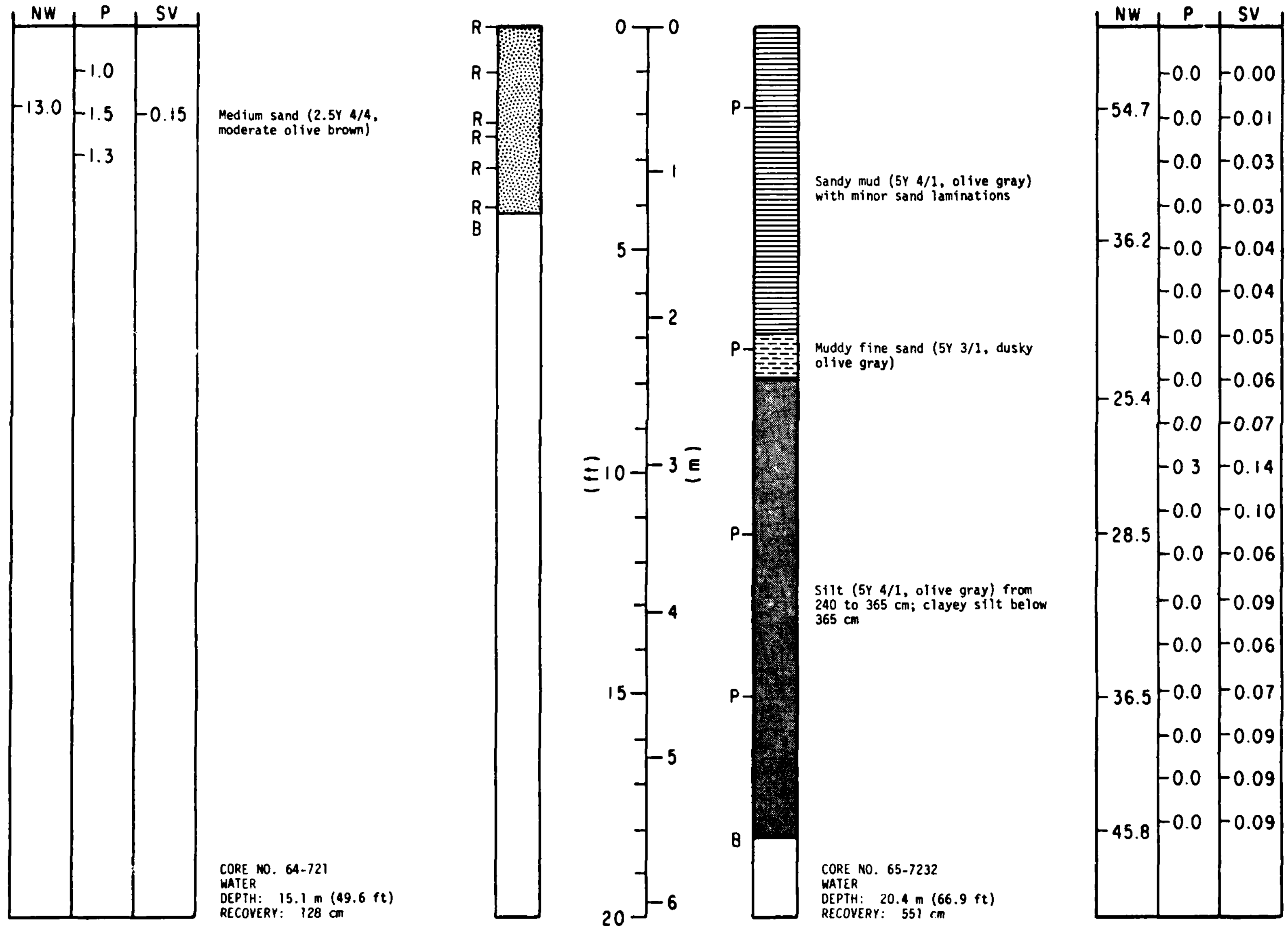

NW
P
SV
50.1
22.2
19.7
22.4
16.8
0.0
0.8
0.2
0.4
0.7
0.3
1.7
1.3
Sandy mud (5Y 3/1, dusky olive gray)
Sandy silt (5Y 3/1, dusky olive gray)
Muddy medium sand (5Y 3/1, dusky olive gray)
Sandy silt (5Y 4/1, olive gray) with minor coarse sand laminations
Gravelly clay or rock (in core bit)
R
R
R
R
S
B
CORE NO. 56-634
WATER DEPTH: 15.9 m (52.3 ft)
RECOVERY: 281 cm
(ft)
0
5
10
15
20
(m)
0
1
2
3
4
5
6
Muddy medium sand (5Y 3/1, dusky olive gray)
Medium sand (2.5Y 3/2, 10YR 4/1, olive-yellow gray) with minor clay laminations
Muddy fine sand (5Y 3/1, dusky olive gray) with clay laminations
Sandy silt (5Y 3/1, dusky olive gray) with gravelly sand at bottom
Gravelly clay (in core bit)
R
R
R
P
P
P
B
CORE NO. 57-7250
WATER DEPTH: 13.6 m (44.6 ft)
RECOVERY: 435 cm
NW
P
SV
15.8
19.2
18.6
20.7
0.7
0.8
0.0
0.9
1.1
0.8
0.8
1.4
0.5
0.6
0.8
1.2
0.7
0.11
0.10
0.11
0.16
0.17
0.15
0.42
0.36
0.26
0.16
0.13
0.26
0.22



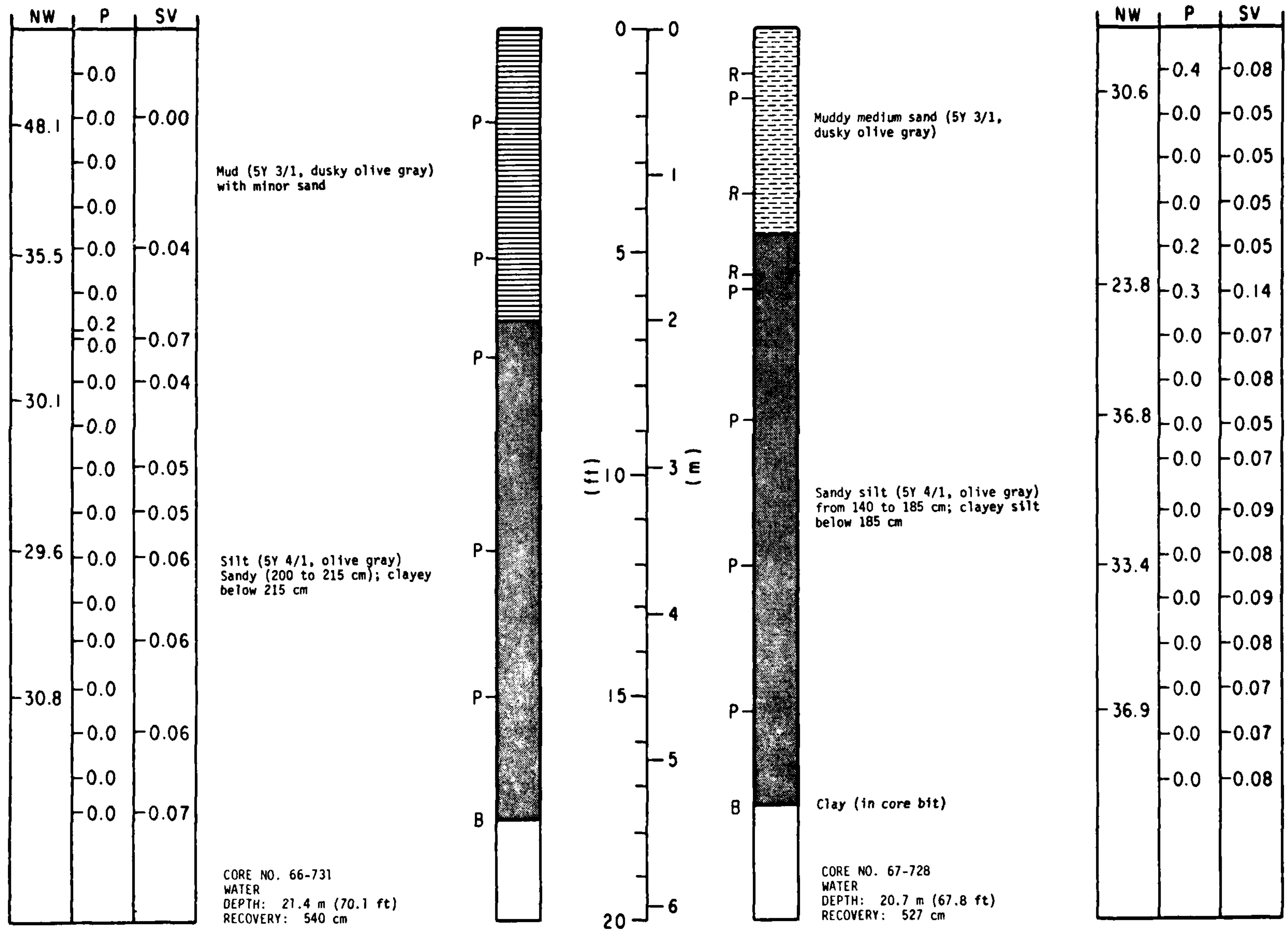
NW
P
SV
16.6
16.3
16.6
17.5
20.2
0.7
0.8
0.8
0.8
0.8
1.0
1.0
1.1
1.3
0.9
0.8
0.0
1.2
1.5
1.5
1.2
0.09
0.14
0.14
0.14
0.12
0.11
0.12
0.13
0.11
0.12
0.10
0.08
0.18
0.20
0.20
0.22
Medium to coarse sand (10Y 3/2, dark yellowish brown, 5Y 2/2, dark olive gray) with minor clay laminations from 0 to 370 cm; fine sand (5Y 3/1, dusky olive gray) with clay laminations below 370 cm
CORE NO. 58-668
WATER
DEPTH: 10.4 m (34.1 ft)
RECOVERY: 542 cm
R
S
R
R
R
R
R
P
R
B
0
5
10
15
20
(ft)
0
1
2
3
4
5
6
(m)
R
R
R
R
P
B
Muddy medium sand (10 Y 3/1, dusky yellowish gray)
Fine sand (5Y 3/2, olive gray) with minor silt laminations
Sandy silt (5Y 3/1, dusky olive gray)
CORE NO. 59-710
WATER
DEPTH: 12.0 m (39.3 ft)
RECOVERY: 253 cm
NW
P
SV
21.4
23.3
0.3
0.7
0.8
0.8
0.5
0.9
1.2
1.2
0.90
0.11
0.14
0.13
0.11
0.15
0.22
0.20

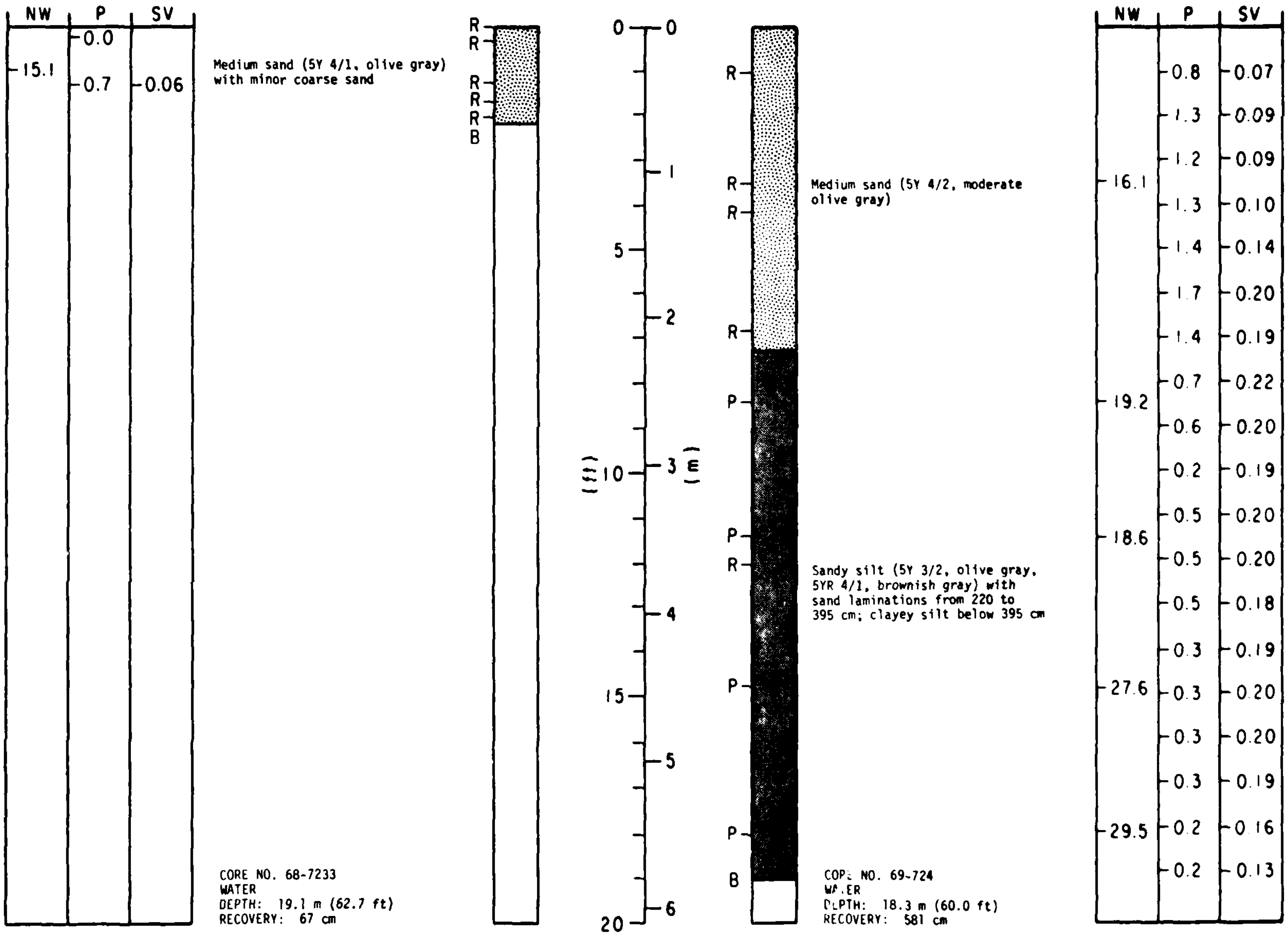

NW
P
SV
18.4
19.7
18.1
21.6
21.1
18.4
0.7
1.1
1.2
1.2
1.2
1.5
1.1
1.6
1.8
0.4
0.6
0.0
0.7
0.4
1.0
1.1
0.8
0.8
0.9
0.8
0.06
0.10
0.09
0.10
0.10
0.09
0.14
0.13
0.15
0.10
0.14
0.13
0.19
0.17
0.25
0.19
0.20
0.21
0.44
Medium sand (5Y 4/1, olive gray) with minor clay laminations, at top grading downward to fine sand with minor clay laminations
Muddy fine sand (5Y 3/1, dusky olive gray) with silt and clay laminations
CORE NO. 60-672
WATER
DEPTH: 13.0 m (42.5 ft)
RECOVERY: 580 cm
Sandy silt (5Y 3/1, dusky olive gray)
Silty gravelly clay (5Y 4/1, olive gray)
R
R
R
R
R
R
P
P
R
P
B
0
5
10
15
20
(ft)
0
1
2
3
4
5
6
(m)
P
P
R
P
P
P
B
Sandy silt (5Y 3/1, dusky olive gray) with sand laminations from 0 to 40 cm; clayey silt with minor sand laminations from 40 to 305 cm
Silty gravelly clay (5Y 5/1, medium olive gray)
CORE NO. 61-675
WATER
DEPTH: 16.0 m (52.4 ft)
RECOVERY: 325 cm
NW
P
SV
49.8
24.6
15.2
0.3
0.7
0.7
0.3
0.0
0.0
0.0
0.5
1.2
2.0
0.02
0.14
0.11
0.21
0.20
0.15
0.10
0.11
0.20
0.73
0.75

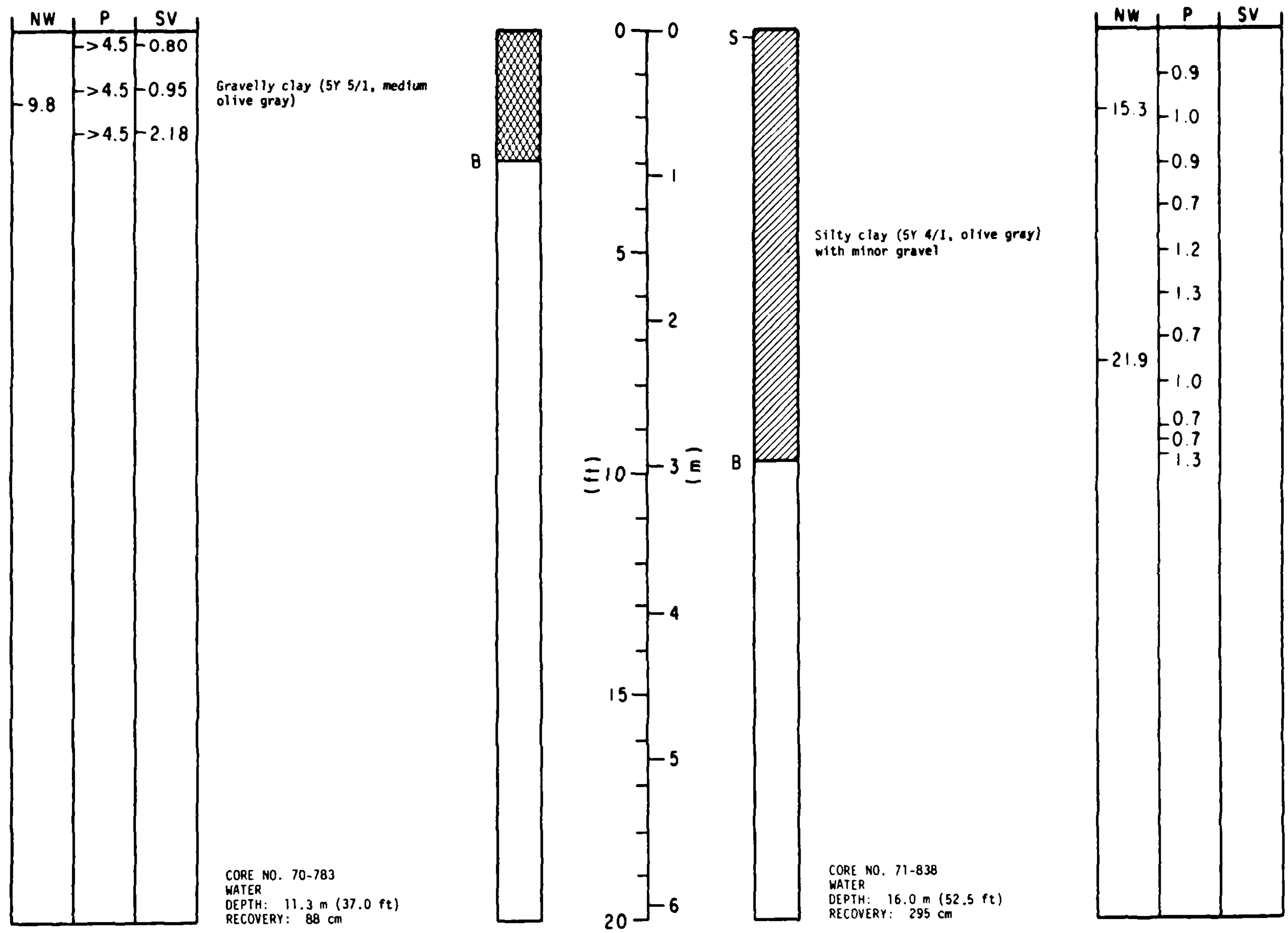

NW
P
SV
60.5
49.1
25.9
39.6
20.9
24.3
15.8
0.0
0.6
0.3
0.2
0.6
1.0
0.10
0.22
0.18
0.07
0.20
0.10
Mud with sand laminations (5Y 3/1, dusky olive gray)
Sandy silt (5Y 4/1, olive gray)
Mud with minor sand laminations (5Y 4/1, olive gray)
Sandy silt (5Y 3/1, dusky olive gray) with sand laminations
Muddy medium sand (5Y 3/1, dusky olive gray) with clay lamination
Sandy silt (5Y 3/1, dusky olive gray) with minor gravel
Gravelly medium sand (5Y 4/2, moderate olive gray)
CORE NO. 62-682
WATER
DEPTH: 17.6 m (57.6 ft)
RECOVERY: 465 cm
R
P
P
P
P
R
R
R
B
0
5
10
15
20
(ft)
0
1
2
3
4
5
6
(m)
R
R
R
R
R
B
Medium to coarse sand (10YR 4/2, dark yellowish brown)
CORE NO. 63-7240
WATER
DEPTH: 14.6 m (47.8 ft)
RECOVERY: 101 cm
NW
P
SV
15.9
0.3
0.8
0.07
0.10

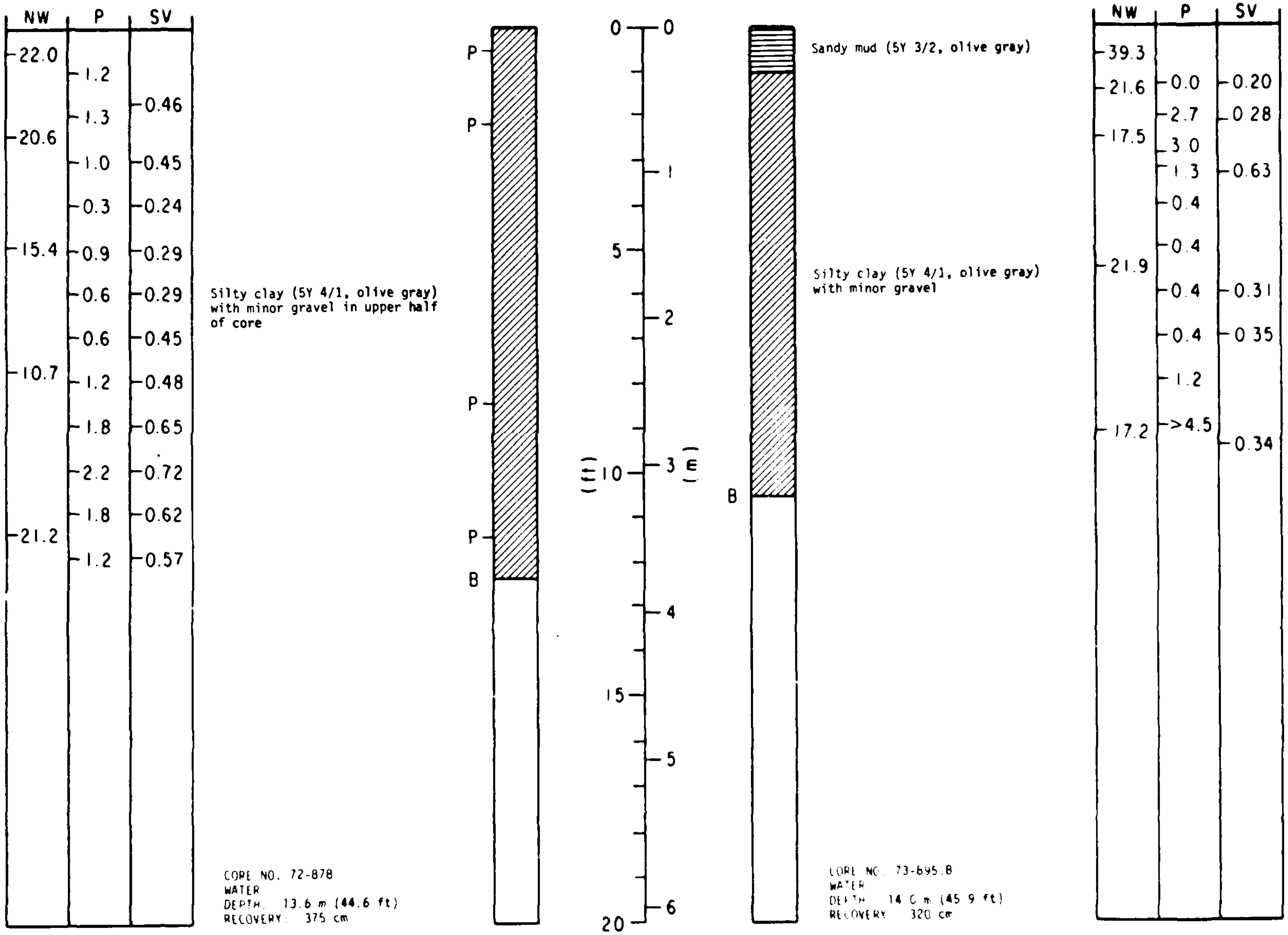


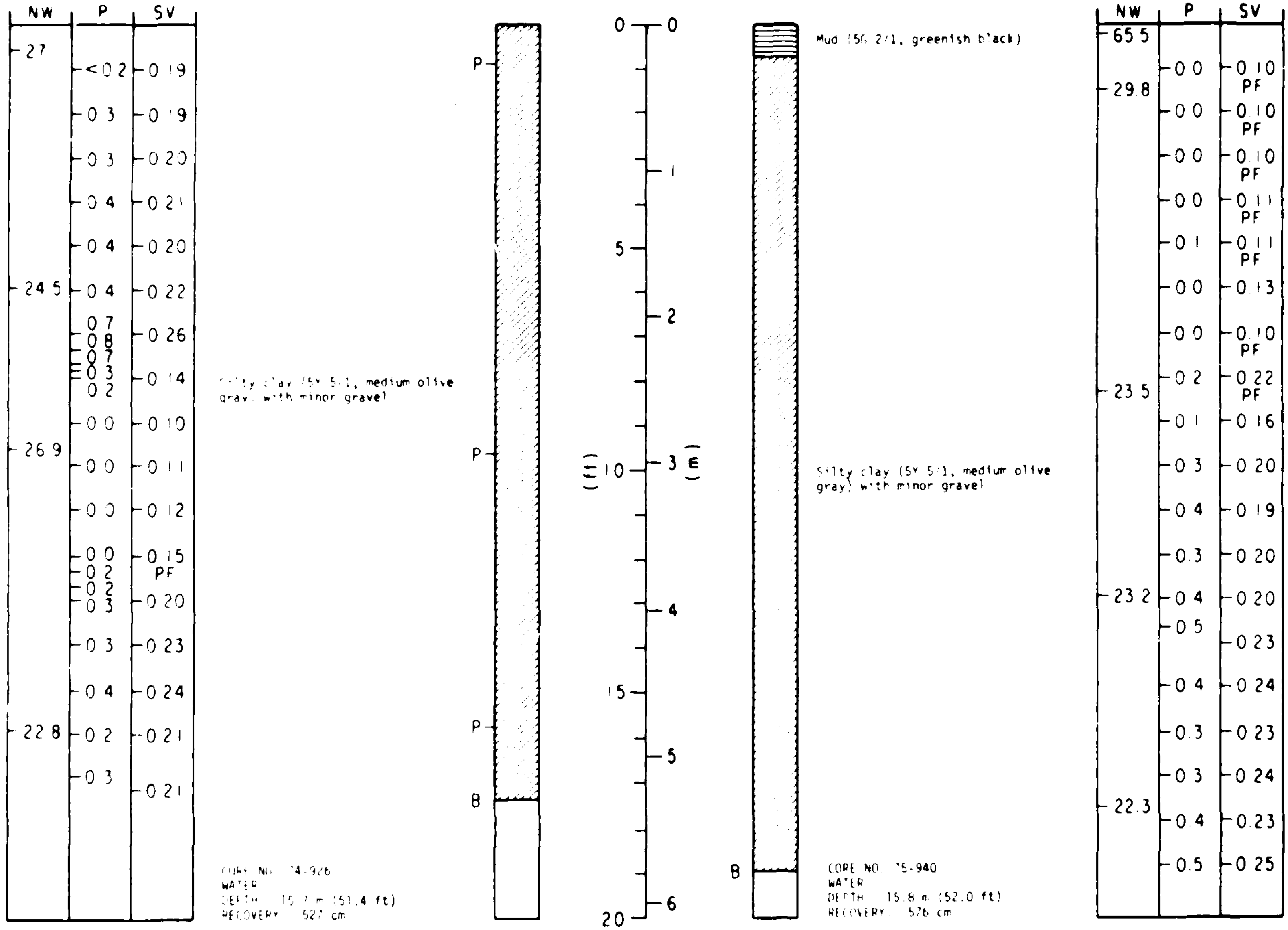
NW
P
SV
13.0
1.0
1.5
1.3
0.15
Medium sand (2.5Y 4/4, moderate olive brown)
CORE NO. 64-721
WATER
DEPTH: 15.1 m (49.6 ft)
RECOVERY: 128 cm
R
B
0
5
10
15
20
(ft)
1
2
3
4
5
6
(m)
P
Sandy mud (5Y 4/1, olive gray) with minor sand laminations
Muddy fine sand (5Y 3/1, dusky olive gray)
Silt (5Y 4/1, olive gray) from 240 to 365 cm; clayey silt below 365 cm
CORE NO. 65-7232
WATER
DEPTH: 20.4 m (66.9 ft)
RECOVERY: 551 cm
54.7
36.2
25.4
28.5
36.5
45.8
0.0
0.3
0.00
0.01
0.03
0.03
0.04
0.04
0.05
0.06
0.07
0.14
0.10
0.06
0.09
0.06
0.07
0.09
0.09
0.09

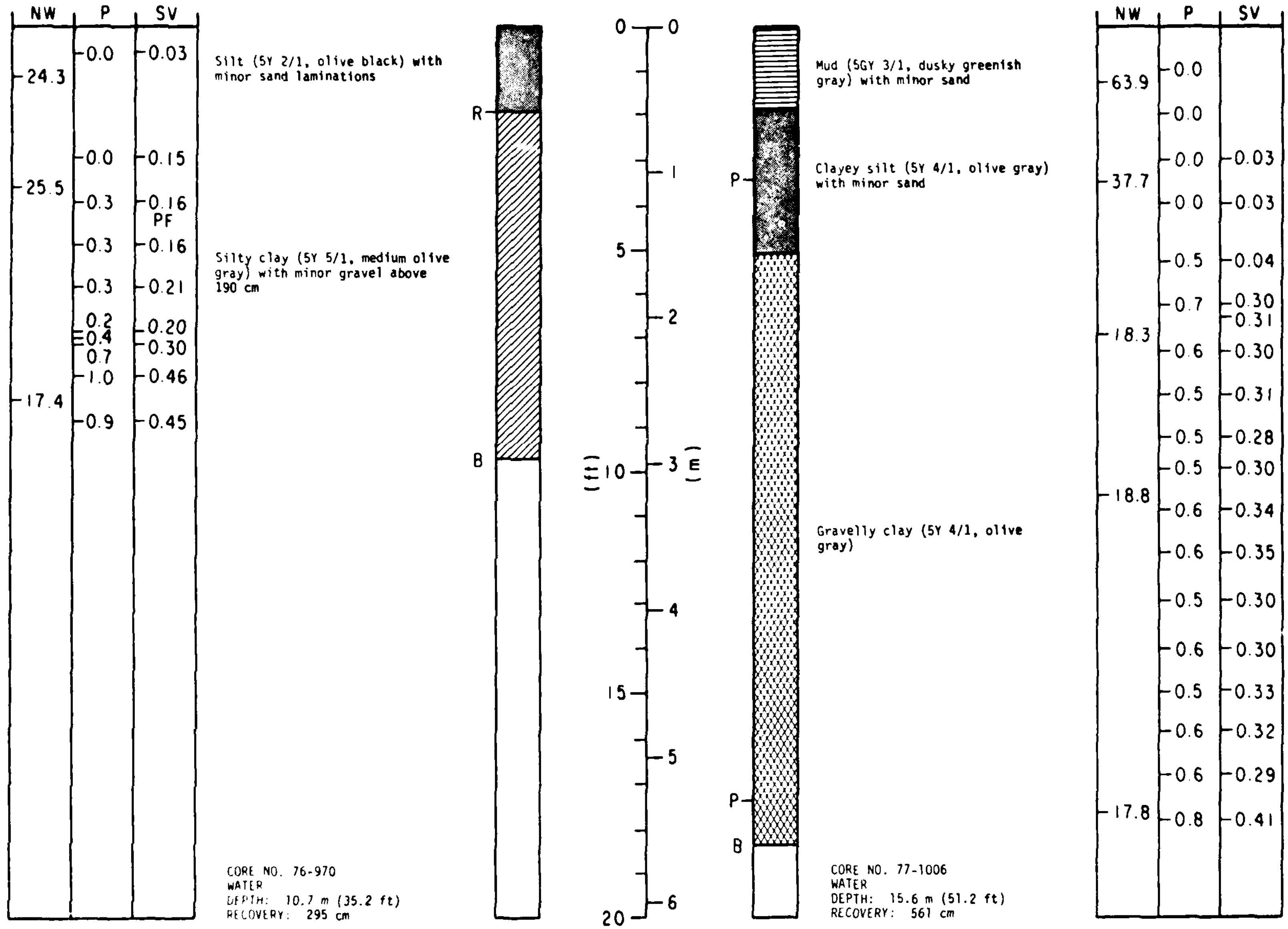

NW
P
SV
48.1
35.5
30.1
29.6
30.8
0.0
0.2
0.00
0.04
0.07
0.05
0.06
Mud (5Y 3/1, dusky olive gray) with minor sand
Silt (5Y 4/1, olive gray) Sandy (200 to 215 cm); clayey below 215 cm
CORE NO. 66-731
WATER
DEPTH: 21.4 m (70.1 ft)
RECOVERY: 540 cm
(ft)
(m)
Muddy medium sand (5Y 3/1, dusky olive gray)
Sandy silt (5Y 4/1, olive gray) from 140 to 185 cm; clayey silt below 185 cm
Clay (in core bit)
CORE NO. 67-728
WATER
DEPTH: 20.7 m (67.8 ft)
RECOVERY: 527 cm
30.6
23.8
36.8
33.4
36.9
0.4
0.3
0.08
0.14
0.09

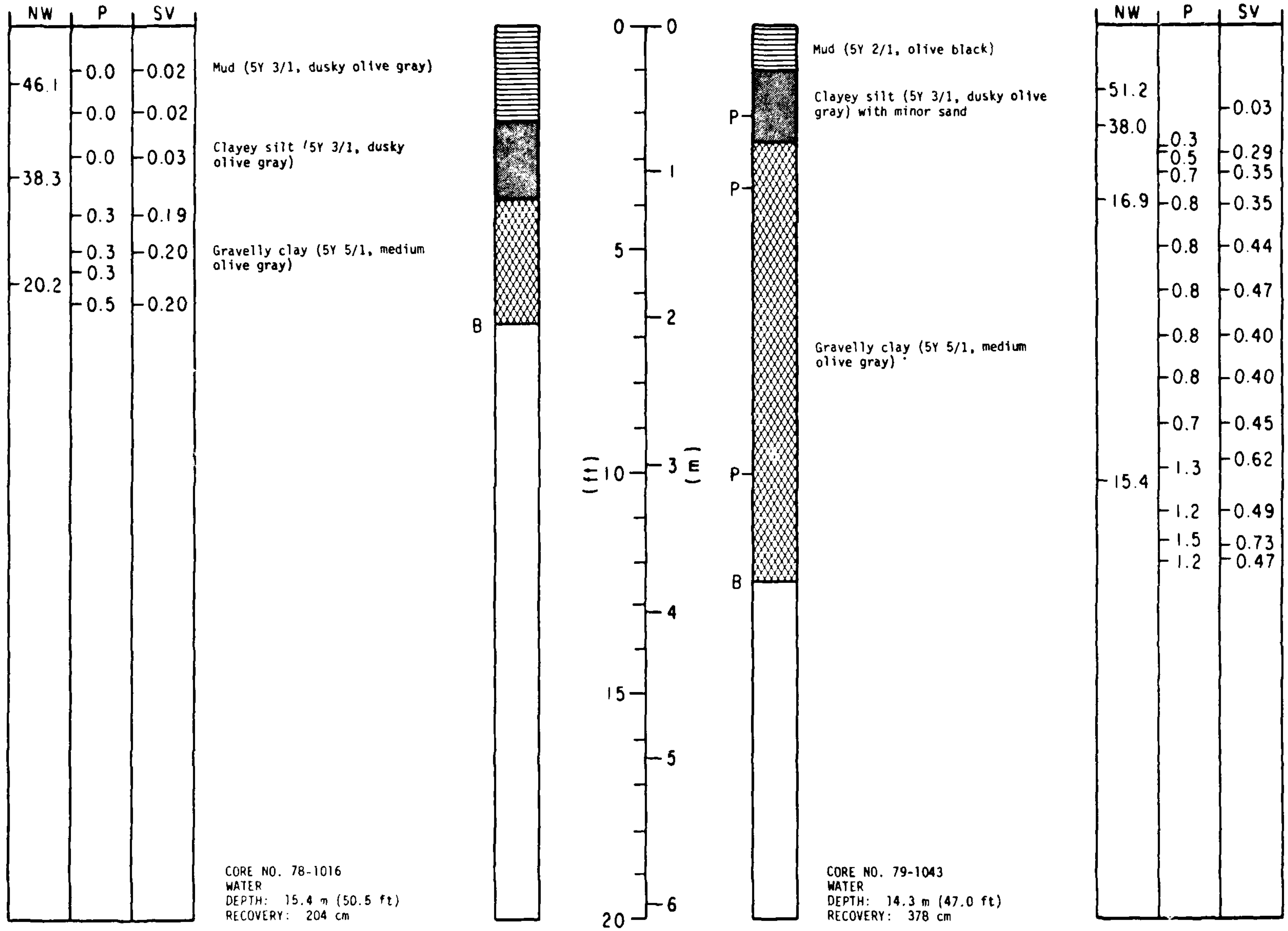

NW
P
SV
15.1
0.0
0.7
0.06
Medium sand (5Y 4/1, olive gray) with minor coarse sand
CORE NO. 68-7233
WATER
DEPTH: 19.1 m (62.7 ft)
RECOVERY: 67 cm
(ft)
(m)
Medium sand (5Y 4/2, moderate olive gray)
Sandy silt (5Y 3/2, olive gray, 5YR 4/1, brownish gray) with sand laminations from 220 to 395 cm; clayey silt below 395 cm
CORE NO. 69-724
WATER
DEPTH: 18.3 m (60.0 ft)
RECOVERY: 581 cm
16.1
19.2
18.6
27.6
29.5
0.8
1.3
1.2
1.3
1.4
1.7
1.4
0.7
0.6
0.2
0.5
0.5
0.5
0.3
0.3
0.3
0.3
0.2
0.2
0.07
0.09
0.09
0.10
0.14
0.20
0.19
0.22
0.20
0.19
0.20
0.20
0.18
0.19
0.20
0.20
0.19
0.16
0.13

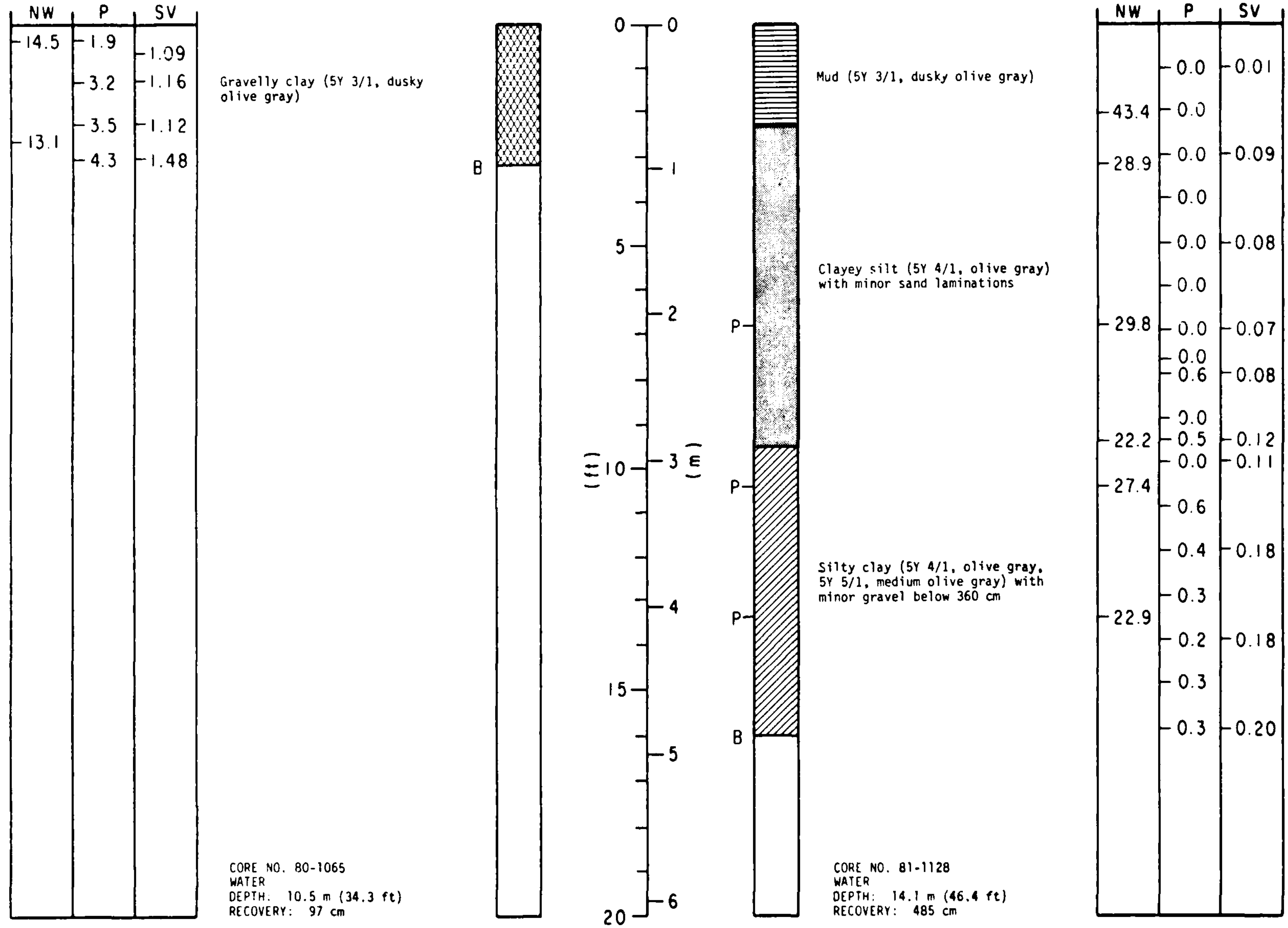

NW
P
SV
>4.5
0.80
>4.5
0.95
>4.5
2.18
9.8
Gravelly clay (5Y 5/1, medium olive gray)
B
CORE NO. 70-783
WATER
DEPTH: 11.3 m (37.0 ft)
RECOVERY: 88 cm
(ft)
0
5
10
15
20
(m)
0
1
2
3
4
5
6
S
B
Silty clay (5Y 4/1, olive gray) with minor gravel
CORE NO. 71-838
WATER
DEPTH: 16.0 m (52.5 ft)
RECOVERY: 295 cm
NW
P
SV
15.3
21.9
0.9
1.0
0.9
0.7
1.2
1.3
0.7
1.0
0.7
0.7
1.3


NW
P
SV
22.0
20.6
15.4
10.7
21.2
1.2
1.3
1.0
0.3
0.9
0.6
0.6
1.2
1.8
2.2
1.8
1.2
0.46
0.45
0.24
0.29
0.29
0.45
0.48
0.65
0.72
0.62
0.57
Silty clay (5Y 4/1, olive gray) with minor gravel in upper half of core
CORE NO. 72-878
WATER
DEPTH 13.6 m (44.6 ft)
RECOVERY 375 cm
P
P
P
P
B
0
5
10
15
20
(ft)
0
1
2
3
4
5
6
(m)
B
Sandy mud (5Y 3/2, olive gray)
Silty clay (5Y 4/1, olive gray) with minor gravel
NW
P
SV
39.3
21.6
17.5
21.9
17.2
0.0
2.7
3.0
1.3
0.4
0.4
0.4
0.4
1.2
>4.5
0.20
0.28
0.63
0.31
0.35
0.34

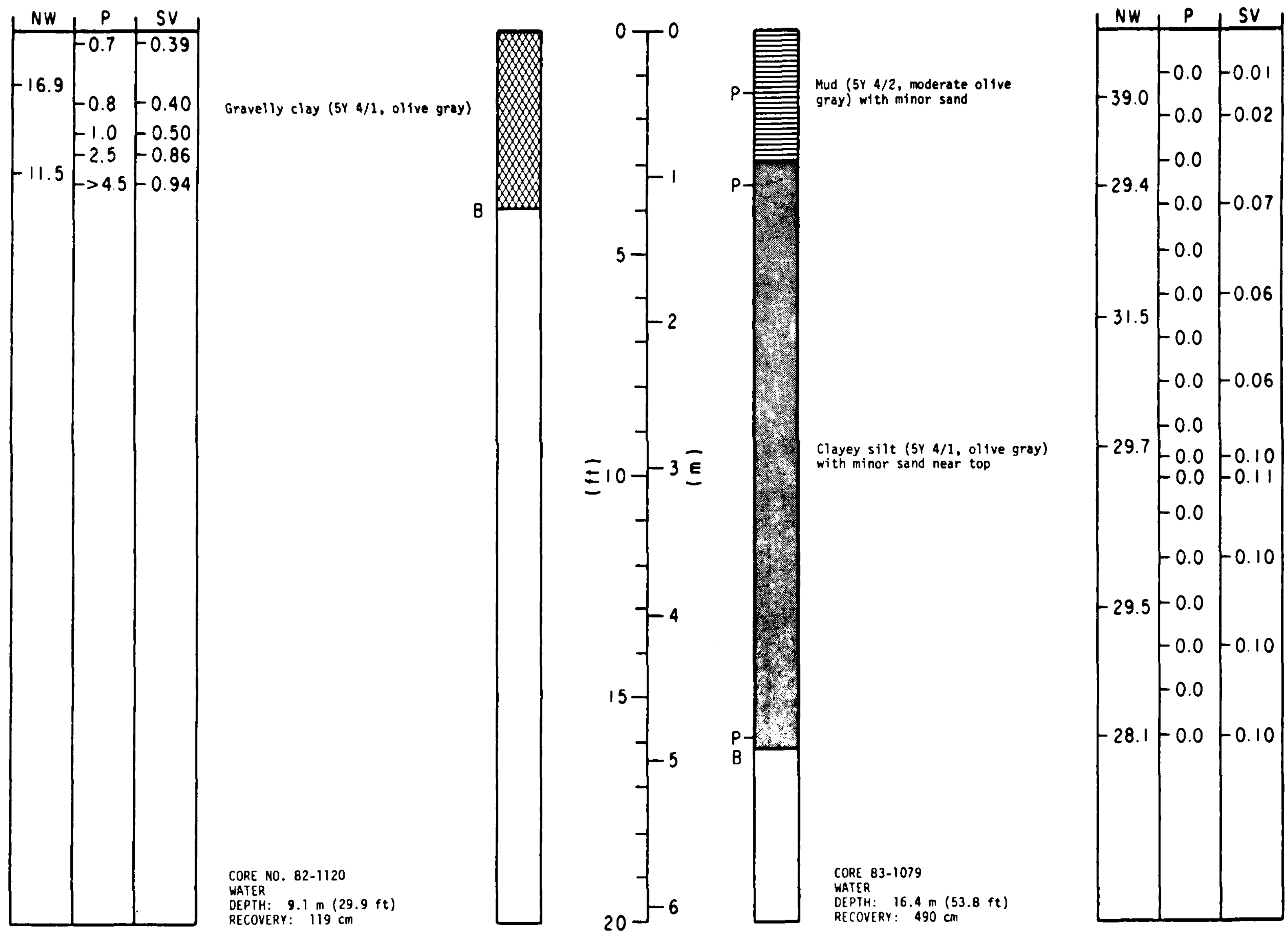

NW
P
SV
27
24 5
26 9
22 8
Silty clay (5Y 5/1, medium olive gray) with minor gravel
CORE NO. 74-926
WATER
DEPTH 15.7 m (51.4 ft)
RECOVERY 527 cm
P
B
0
5
10
15
20
(ft)
(m)
1
2
3
4
5
6
Mud (5G 2/1, greenish black)
Silty clay (5Y 5/1, medium olive gray) with minor gravel
CORE NO. 75-940
WATER
DEPTH 15.8 m (52.0 ft)
RECOVERY 576 cm
65.5
29.8
23.5
23.2
22.3
PF


NW
P
SV
24.3
25.5
17.4
0.0
0.0
0.3
0.3
0.3
0.2
0.4
0.7
1.0
0.9
0.03
0.15
0.16
PF
0.16
0.21
0.20
0.30
0.46
0.45
Silt (5Y 2/1, olive black) with minor sand laminations
Silty clay (5Y 5/1, medium olive gray) with minor gravel above 190 cm
CORE NO. 76-970
WATER
DEPTH: 10.7 m (35.2 ft)
RECOVERY: 295 cm
R
B
0
5
10
15
20
(ft)
0
1
2
3
4
5
6
(m)
P
P
B
Mud (5GY 3/1, dusky greenish gray) with minor sand
Clayey silt (5Y 4/1, olive gray) with minor sand
Gravelly clay (5Y 4/1, olive gray)
CORE NO. 77-1006
WATER
DEPTH: 15.6 m (51.2 ft)
RECOVERY: 561 cm
NW
P
SV
63.9
37.7
18.3
18.8
17.8
0.0
0.0
0.0
0.0
0.5
0.7
0.6
0.5
0.5
0.5
0.6
0.6
0.5
0.6
0.5
0.6
0.6
0.8
0.03
0.03
0.04
0.30
0.31
0.30
0.31
0.28
0.30
0.34
0.35
0.30
0.30
0.33
0.32
0.29
0.41

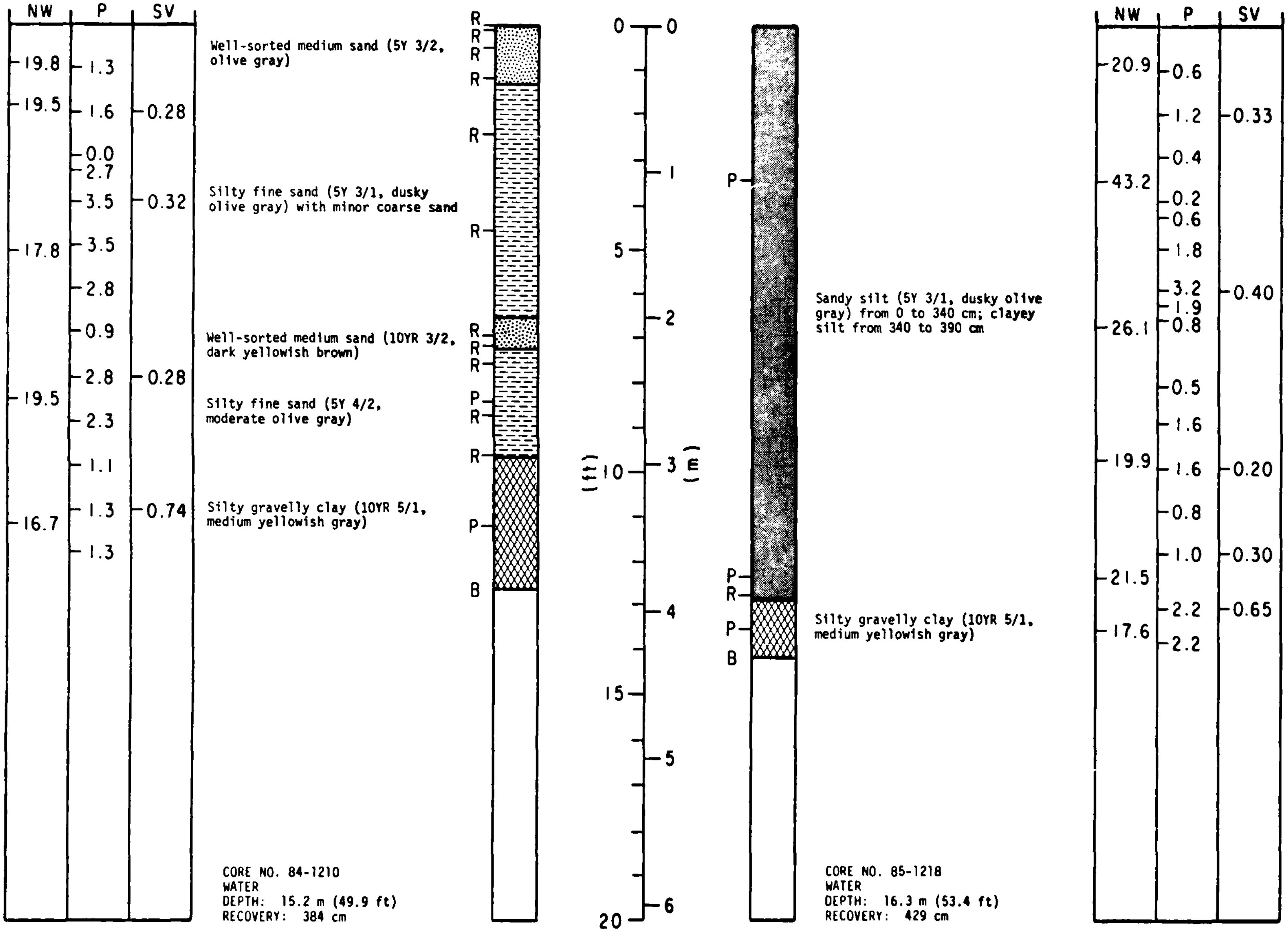

NW
P
SV
46.1
38.3
20.2
0.0
0.0
0.0
0.3
0.3
0.3
0.5
0.02
0.02
0.03
0.19
0.20
0.20
Mud (5Y 3/1, dusky olive gray)
Clayey silt (5Y 3/1, dusky olive gray)
Gravelly clay (5Y 5/1, medium olive gray)
CORE NO. 78-1016
WATER
DEPTH: 15.4 m (50.5 ft)
RECOVERY: 204 cm
B
0
5
10
15
20
(ft)
0
1
2
3
4
5
6
(m)
P
P
P
B
Mud (5Y 2/1, olive black)
Clayey silt (5Y 3/1, dusky olive gray) with minor sand
Gravelly clay (5Y 5/1, medium olive gray)
CORE NO. 79-1043
WATER
DEPTH: 14.3 m (47.0 ft)
RECOVERY: 378 cm
NW
P
SV
51.2
38.0
16.9
15.4
0.3
0.5
0.7
0.8
0.8
0.8
0.8
0.8
0.7
1.3
1.2
1.5
1.2
0.03
0.29
0.35
0.35
0.44
0.47
0.40
0.40
0.45
0.62
0.49
0.73
0.47



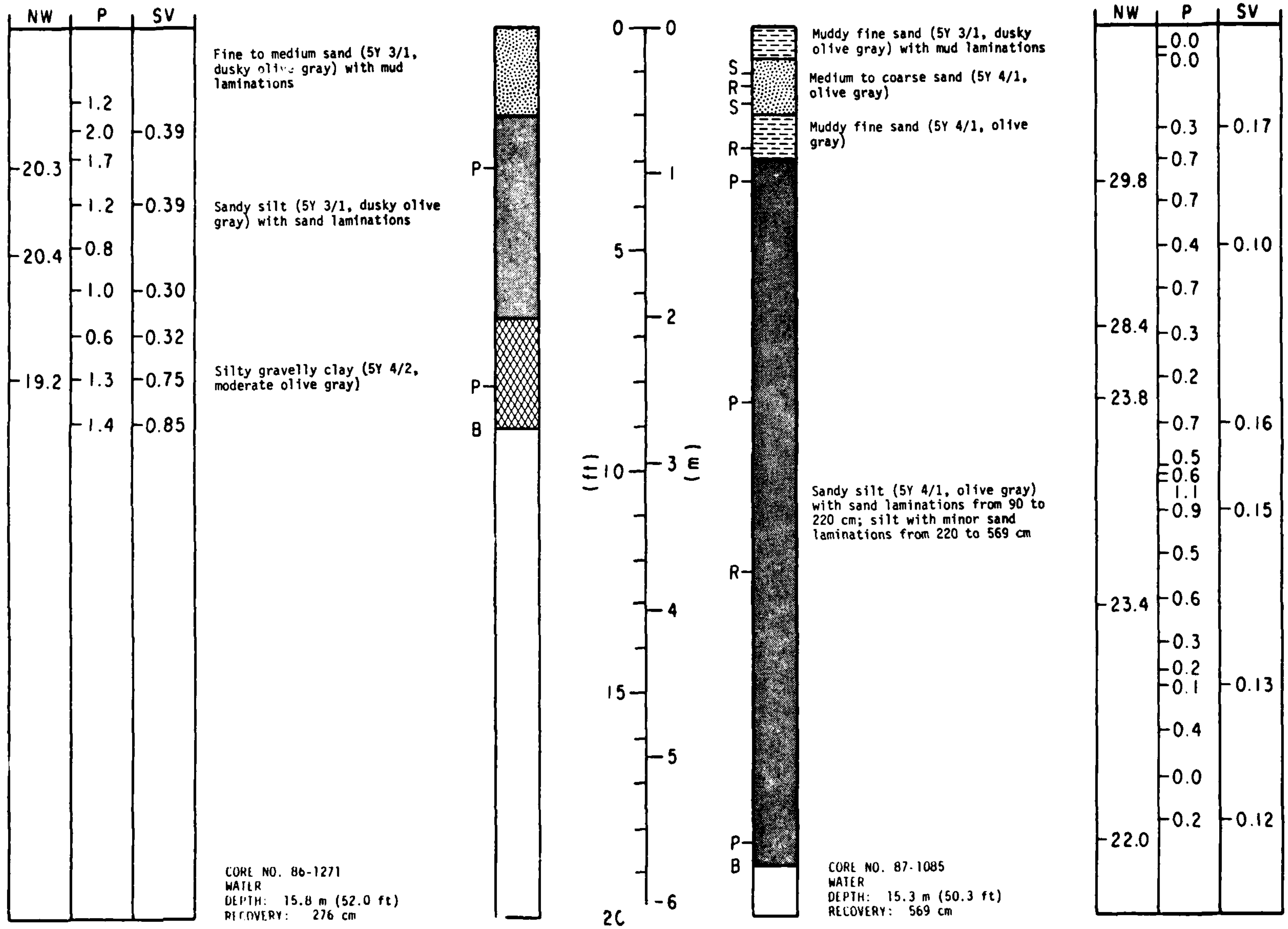
NW
P
SV
14.5
13.1
1.9
3.2
3.5
4.3
1.09
1.16
1.12
1.48
Gravelly clay (5Y 3/1, dusky olive gray)
CORE NO. 80-1065
WATER DEPTH: 10.5 m (34.3 ft)
RECOVERY: 97 cm
B
0
5
10
15
20
(ft)
0
1
2
3
4
5
6
(m)
P
P
P
B
Mud (5Y 3/1, dusky olive gray)
Clayey silt (5Y 4/1, olive gray) with minor sand laminations
Silty clay (5Y 4/1, olive gray, 5Y 5/1, medium olive gray) with minor gravel below 360 cm
CORE NO. 81-1128
WATER DEPTH: 14.1 m (46.4 ft)
RECOVERY: 485 cm
NW
P
SV
43.4
28.9
29.8
22.2
27.4
22.9
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.6
0.0
0.5
0.0
0.6
0.4
0.3
0.2
0.3
0.3
0.01
0.09
0.08
0.07
0.08
0.12
0.11
0.18
0.18
0.20



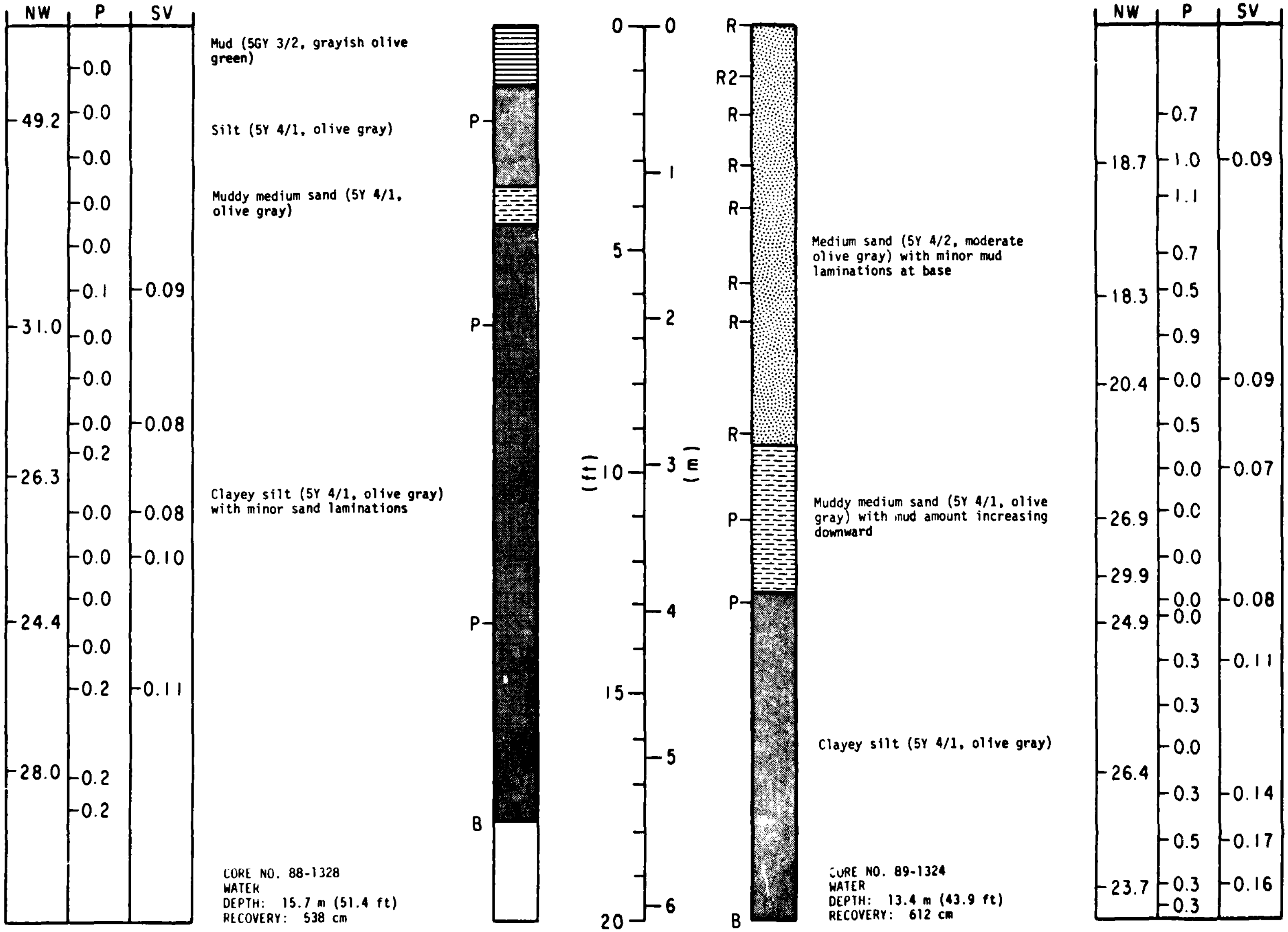
NW
P
SV
16.9
11.5
0.7
0.8
1.0
2.5
>4.5
0.39
0.40
0.50
0.86
0.94
Gravelly clay (5Y 4/1, olive gray)
B
CORE NO. 82-1120
WATER
DEPTH: 9.1 m (29.9 ft)
RECOVERY: 119 cm
(ft)
(m)
0
5
10
15
20
1
2
3
4
6
P
P
P
B
Mud (5Y 4/2, moderate olive gray) with minor sand
Clayey silt (5Y 4/1, olive gray) with minor sand near top
CORE 83-1079
WATER
DEPTH: 16.4 m (53.8 ft)
RECOVERY: 490 cm
NW
P
SV
39.0
29.4
31.5
29.7
29.5
28.1
0.0
0.01
0.02
0.07
0.06
0.06
0.10
0.11
0.10
0.10
0.10

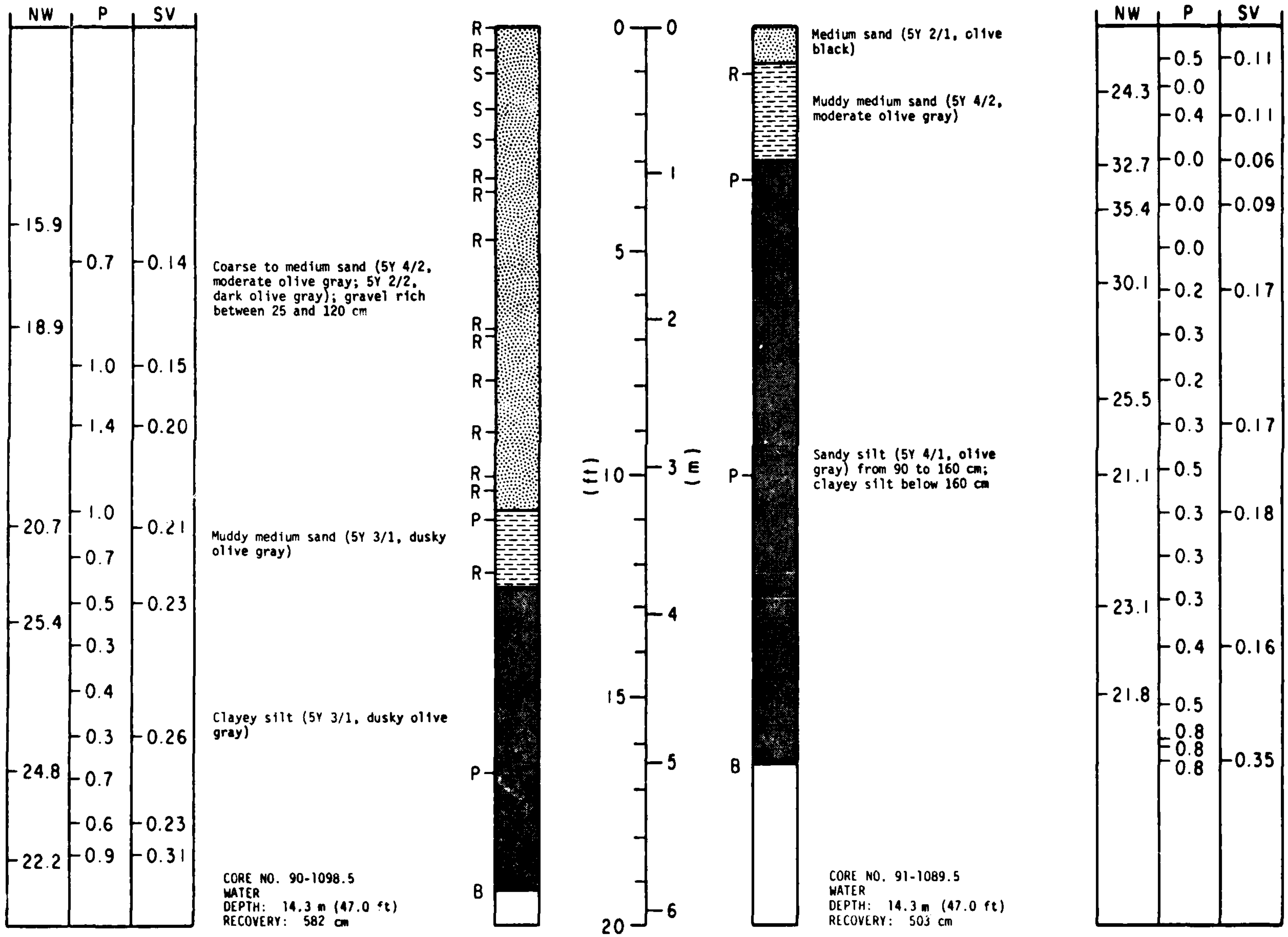


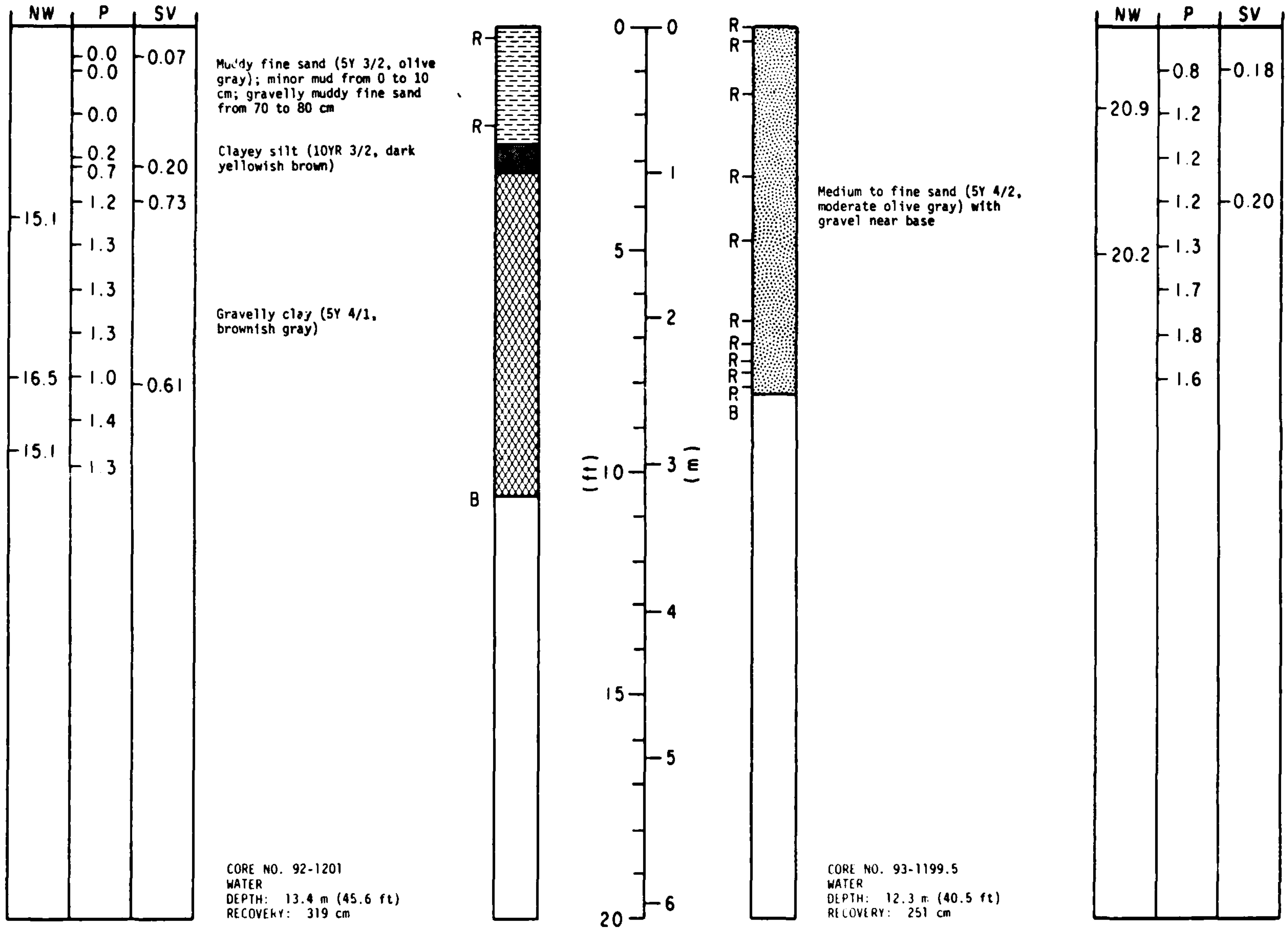
NW
P
SV
19.8
19.5
17.8
19.5
16.7
1.3
1.6
0.0
2.7
3.5
3.5
2.8
0.9
2.8
2.3
1.1
1.3
1.3
0.28
0.32
0.28
0.74
Well-sorted medium sand (5Y 3/2, olive gray)
Silty fine sand (5Y 3/1, dusky olive gray) with minor coarse sand
Well-sorted medium sand (10YR 3/2, dark yellowish brown)
Silty fine sand (5Y 4/2, moderate olive gray)
Silty gravelly clay (10YR 5/1, medium yellowish gray)
CORE NO. 84-1210
WATER
DEPTH: 15.2 m (49.9 ft)
RECOVERY: 384 cm
(ft)
(m)
Sandy silt (5Y 3/1, dusky olive gray) from 0 to 340 cm; clayey silt from 340 to 390 cm
Silty gravelly clay (10YR 5/1, medium yellowish gray)
CORE NO. 85-1218
WATER
DEPTH: 16.3 m (53.4 ft)
RECOVERY: 429 cm
20.9
43.2
26.1
19.9
21.5
17.6
0.6
1.2
0.4
0.2
0.6
1.8
3.2
1.9
0.8
0.5
1.6
1.6
0.8
1.0
2.2
2.2
0.33
0.40
0.20
0.30
0.65

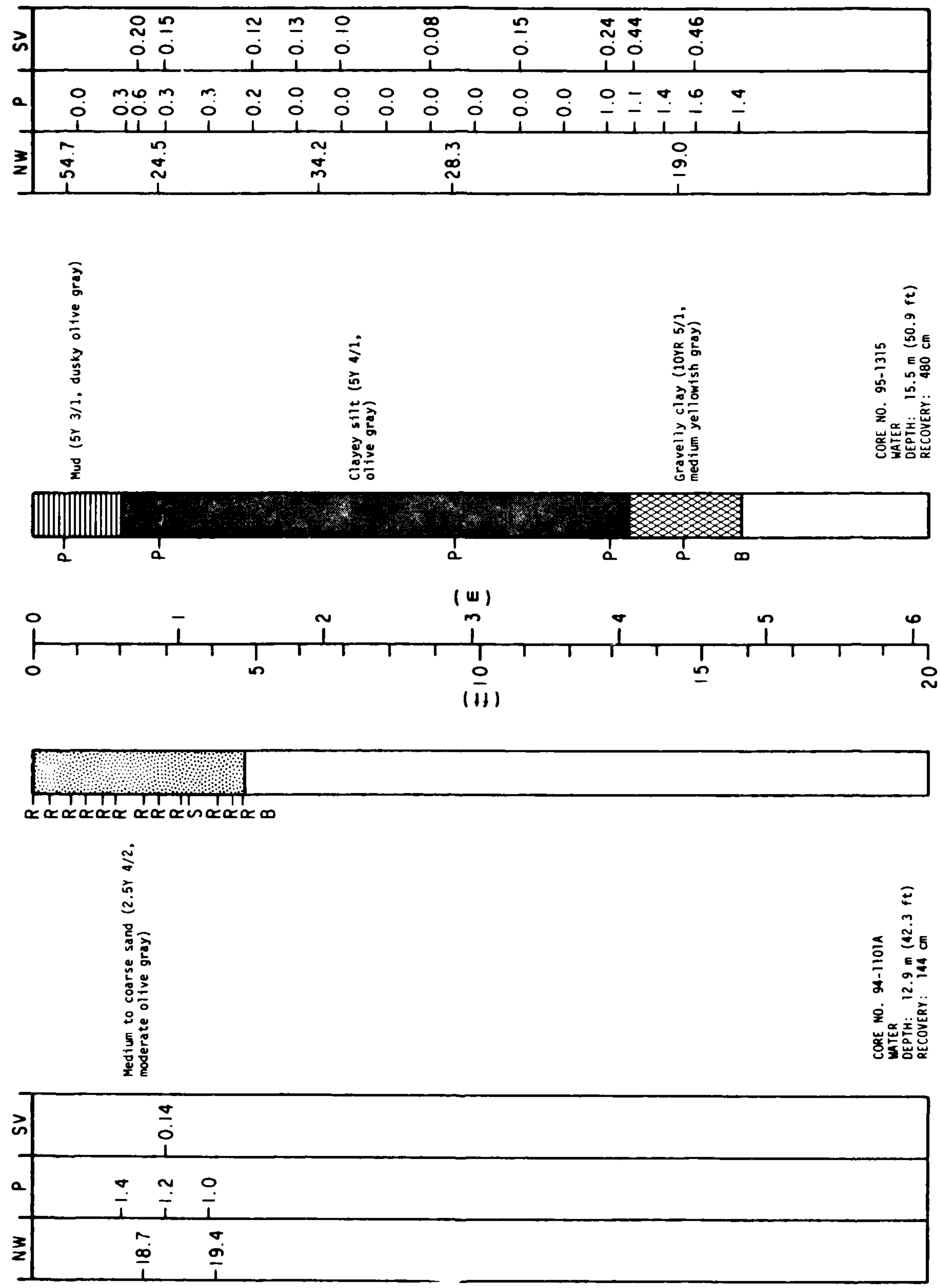


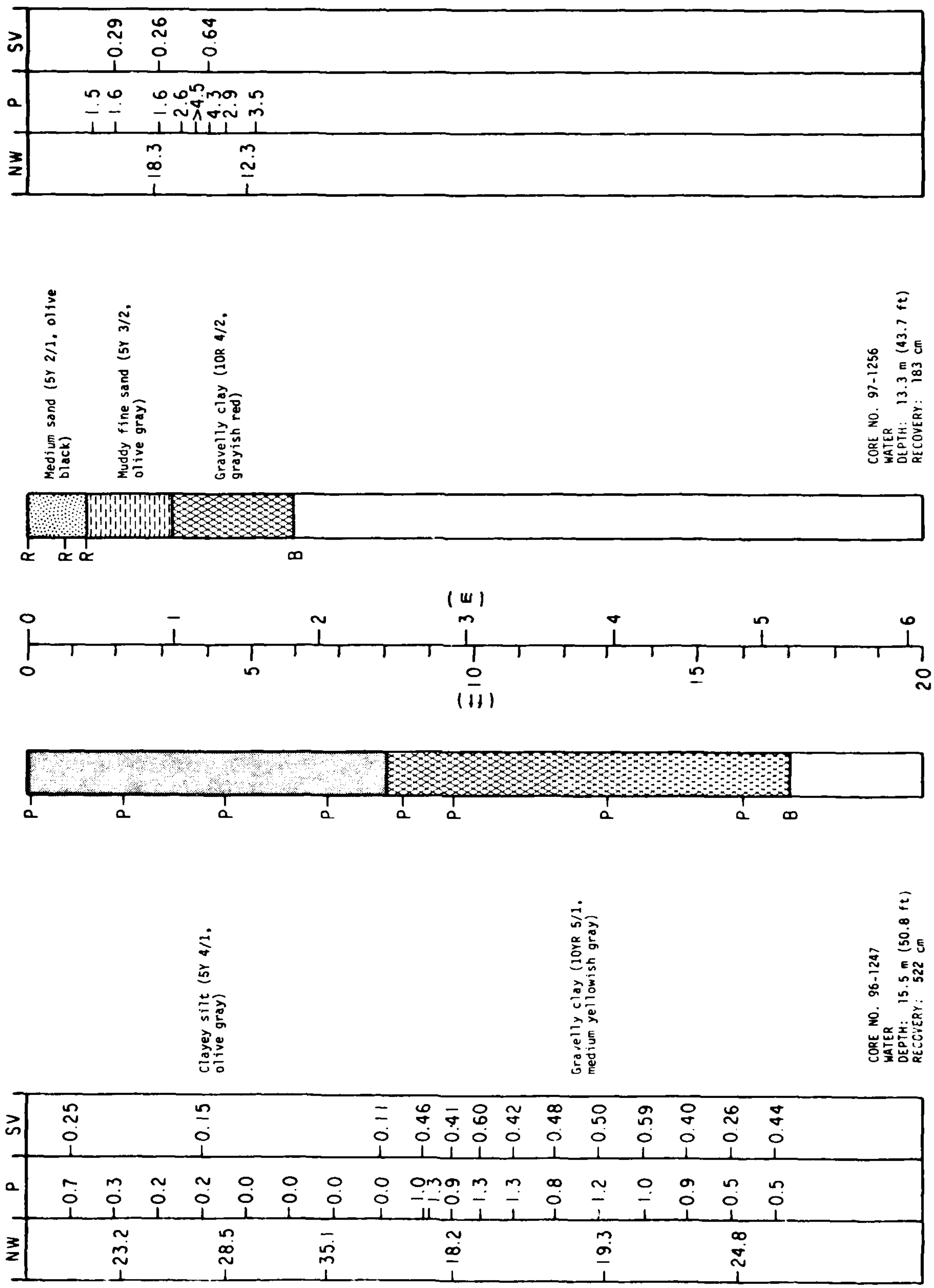
NW
P
SV
Fine to medium sand (5Y 3/1, dusky olive gray) with mud laminations
Sandy silt (5Y 3/1, dusky olive gray) with sand laminations
Silty gravelly clay (5Y 4/2, moderate olive gray)
CORE NO. 86-1271
WATER
DEPTH: 15.8 m (52.0 ft)
RECOVERY: 276 cm
(ft)
(m)
Muddy fine sand (5Y 3/1, dusky olive gray) with mud laminations
Medium to coarse sand (5Y 4/1, olive gray)
Muddy fine sand (5Y 4/1, olive gray)
Sandy silt (5Y 4/1, olive gray) with sand laminations from 90 to 220 cm; silt with minor sand laminations from 220 to 569 cm
CORE NO. 87-1085
WATER
DEPTH: 15.3 m (50.3 ft)
RECOVERY: 569 cm


NW
P
SV
Mud (5GY 3/2, grayish olive green)
Silt (5Y 4/1, olive gray)
Muddy medium sand (5Y 4/1, olive gray)
Clayey silt (5Y 4/1, olive gray) with minor sand laminations
CORE NO. 88-1328
WATER
DEPTH: 15.7 m (51.4 ft)
RECOVERY: 538 cm
(ft)
(m)
Medium sand (5Y 4/2, moderate olive gray) with minor mud laminations at base
Muddy medium sand (5Y 4/1, olive gray) with mud amount increasing downward
Clayey silt (5Y 4/1, olive gray)
CORE NO. 89-1324
WATER
DEPTH: 13.4 m (43.9 ft)
RECOVERY: 612 cm

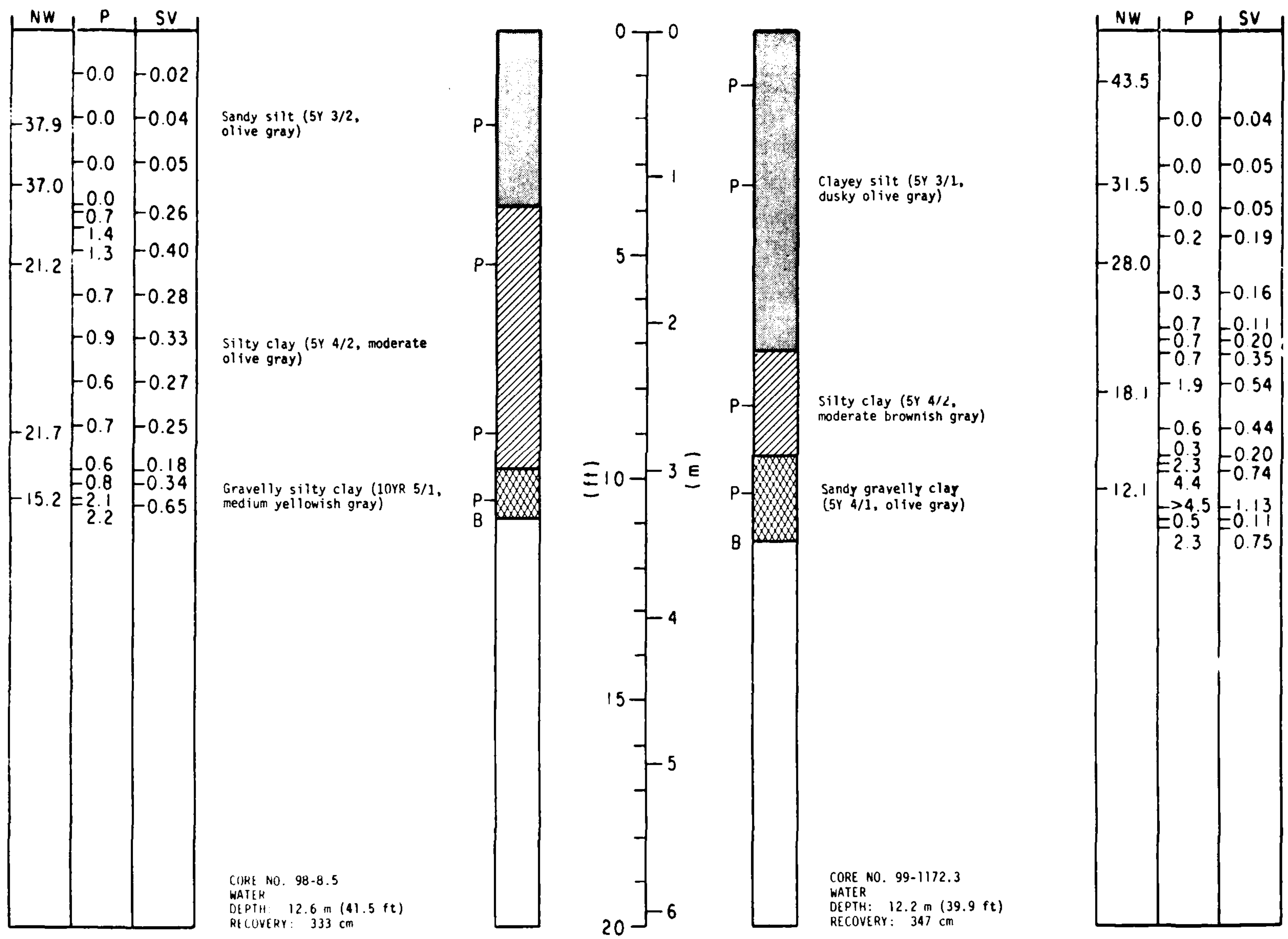

NW
P
SV
15.9
18.9
20.7
25.4
24.8
22.2
0.7
1.0
1.4
1.0
0.7
0.5
0.3
0.4
0.3
0.7
0.6
0.9
0.14
0.15
0.20
0.21
0.23
0.26
0.23
0.31
Coarse to medium sand (5Y 4/2, moderate olive gray; 5Y 2/2, dark olive gray); gravel rich between 25 and 120 cm
Muddy medium sand (5Y 3/1, dusky olive gray)
Clayey silt (5Y 3/1, dusky olive gray)
CORE NO. 90-1098.5
WATER
DEPTH: 14.3 m (47.0 ft)
RECOVERY: 582 cm
R
R
S
S
S
R
R
R
R
R
R
R
R
R
P
R
P
B
(ft)
0
5
10
15
20
(m)
0
1
2
3
4
5
6
R
P
P
B
Medium sand (5Y 2/1, olive black)
Muddy medium sand (5Y 4/2, moderate olive gray)
Sandy silt (5Y 4/1, olive gray) from 90 to 160 cm; clayey silt below 160 cm
CORE NO. 91-1089.5
WATER
DEPTH: 14.3 m (47.0 ft)
RECOVERY: 503 cm
NW
P
SV
24.3
32.7
35.4
30.1
25.5
21.1
23.1
21.8
0.5
0.0
0.4
0.0
0.0
0.0
0.2
0.3
0.2
0.3
0.5
0.3
0.3
0.3
0.4
0.5
0.8
0.8
0.8
0.11
0.11
0.06
0.09
0.17
0.17
0.18
0.16
0.35

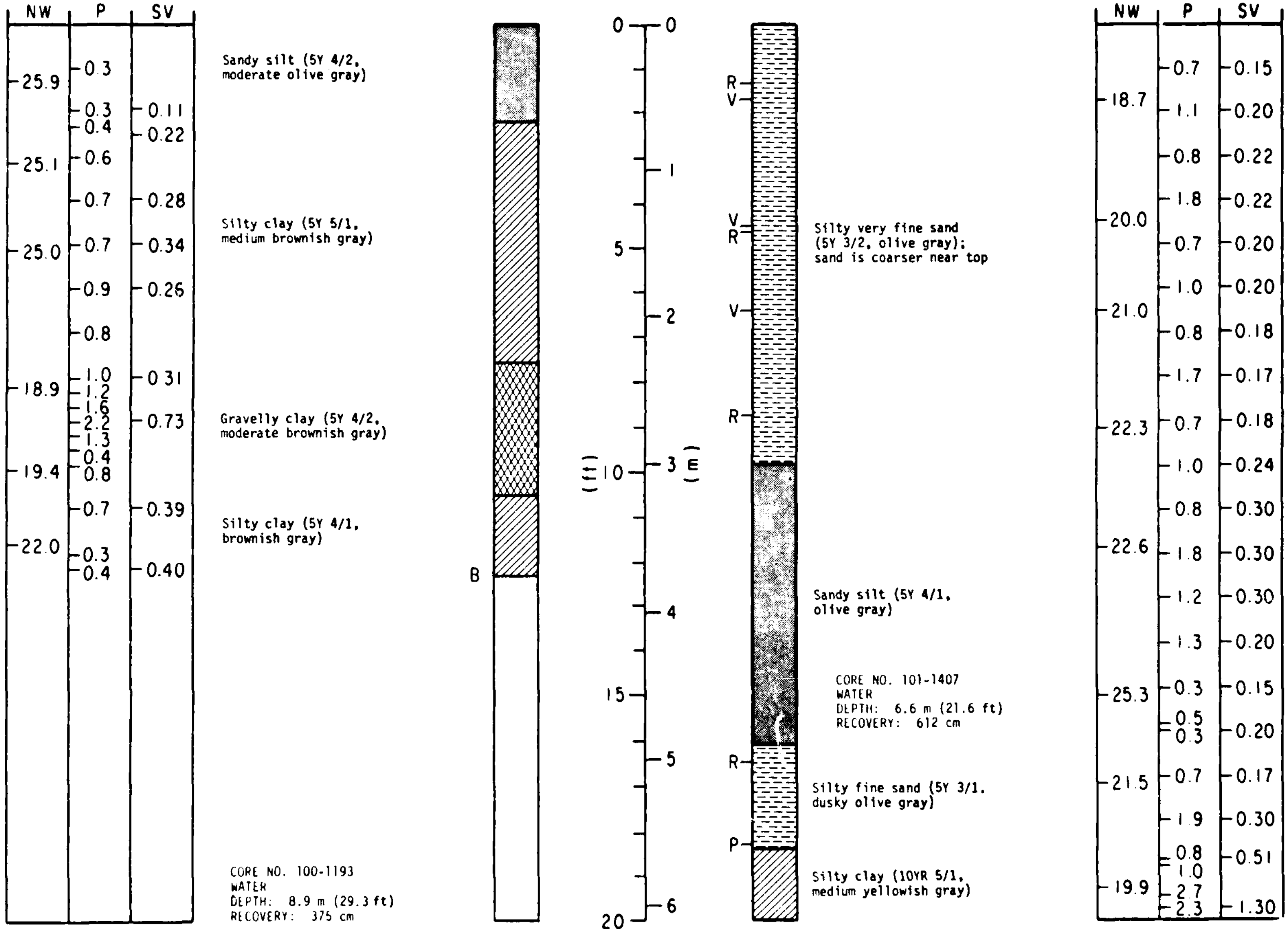

NW
P
SV
0.0
0.0
0.0
0.2
0.7
1.2
1.3
1.3
1.3
1.0
1.4
1.3
15.1
16.5
15.1
0.07
0.20
0.73
0.61
Muddy fine sand (5Y 3/2, olive gray); minor mud from 0 to 10 cm; gravelly muddy fine sand from 70 to 80 cm
Clayey silt (10YR 3/2, dark yellowish brown)
Gravelly clay (5Y 4/1, brownish gray)
R
R
B
CORE NO. 92-1201
WATER
DEPTH: 13.4 m (45.6 ft)
RECOVERY: 319 cm
0
5
10
15
20
(ft)
0
1
2
3
4
5
6
(m)
R
R
R
R
R
R
R
R
R
R
B
Medium to fine sand (5Y 4/2, moderate olive gray) with gravel near base
CORE NO. 93-1199.5
WATER
DEPTH: 12.3 m (40.5 ft)
RECOVERY: 251 cm
NW
P
SV
20.9
20.2
0.8
1.2
1.2
1.2
1.3
1.7
1.8
1.6
0.18
0.20

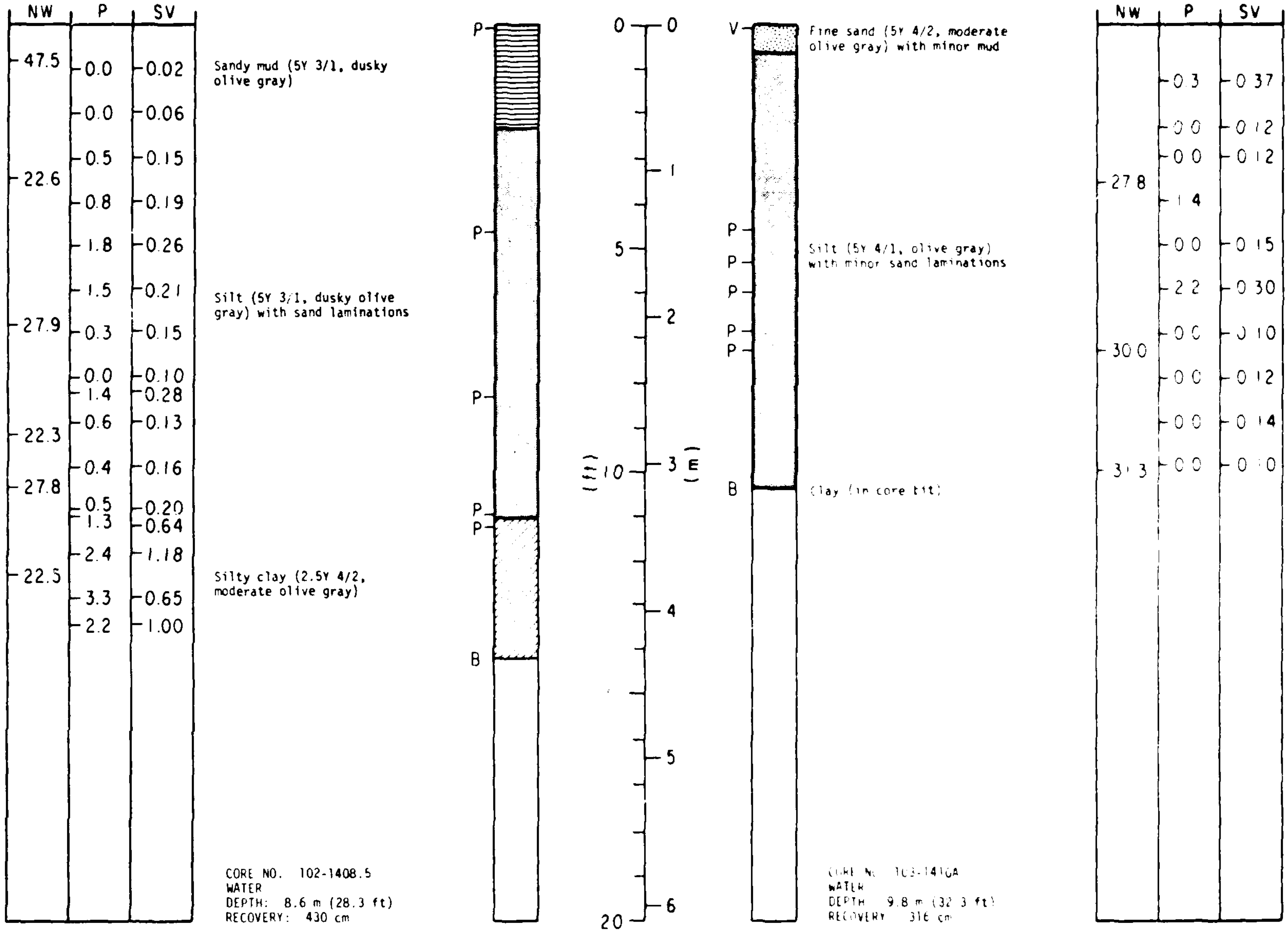

SV
P
NW
0.20
0.15
0.12
0.13
0.10
0.08
0.15
0.24
0.44
0.46
0.0
0.3
0.6
0.3
0.3
0.2
0.0
0.0
0.0
0.0
0.0
0.0
0.0
1.0
1.1
1.4
1.6
1.4
54.7
24.5
34.2
28.3
19.0
Mud (5Y 3/1, dusky olive gray)
Clayey silt (5Y 4/1, olive gray)
Gravelly clay (10YR 5/1, medium yellowish gray)
CORE NO. 95-1315
WATER DEPTH: 15.5 m (50.9 ft)
RECOVERY: 480 cm
(m)
(ft)
Medium to coarse sand (2.5Y 4/2, moderate olive gray)
CORE NO. 94-1101A
WATER DEPTH: 12.9 m (42.3 ft)
RECOVERY: 144 cm
0.14
1.4
1.2
1.0
18.7
19.4



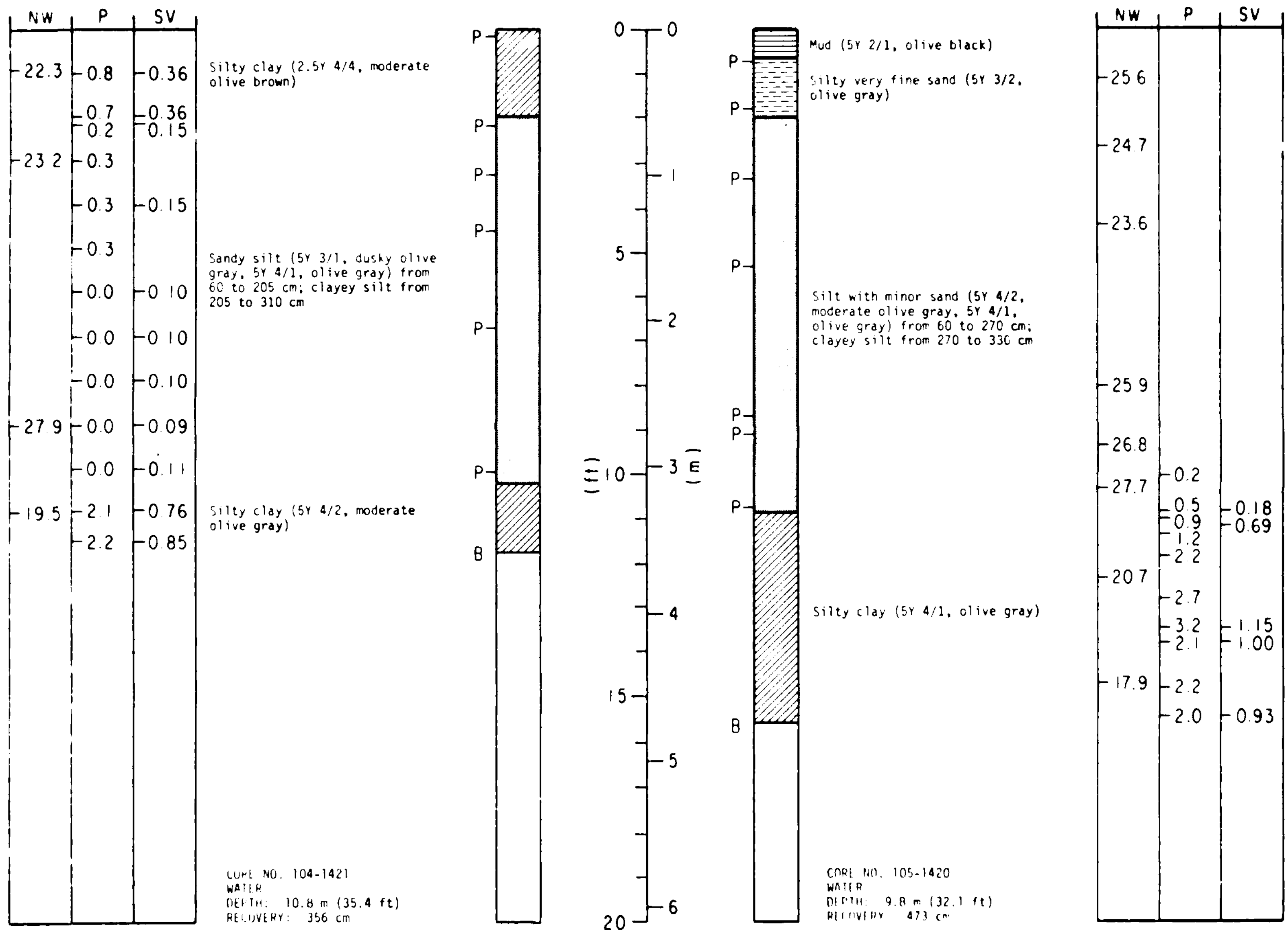
NW
P
SV
18.3
12.3
1.5
1.6
1.6
2.6
>4.5
4.3
2.9
3.5
0.29
0.26
0.64
Medium sand (5Y 2/1, olive black)
Muddy fine sand (5Y 3/2, olive gray)
Gravelly clay (10R 4/2, grayish red)
R
R
R
B
CORE NO. 97-1256
WATER DEPTH: 13.3 m (43.7 ft)
RECOVERY: 183 cm
(m)
0
1
2
3
4
5
6
(ft)
0
5
10
15
20
P
P
P
P
P
P
P
P
B
Clayey silt (5Y 4/1, olive gray)
Gravelly clay (10YR 5/1, medium yellowish gray)
CORE NO. 96-1247
WATER DEPTH: 15.5 m (50.8 ft)
RECOVERY: 522 cm
23.2
28.5
35.1
18.2
19.3
24.8
0.7
0.3
0.2
0.2
0.0
0.0
0.0
0.0
1.0
1.3
0.9
1.3
1.3
0.8
1.2
1.0
0.9
0.5
0.5
0.25
0.15
0.11
0.46
0.41
0.60
0.42
0.48
0.50
0.59
0.40
0.26
0.44

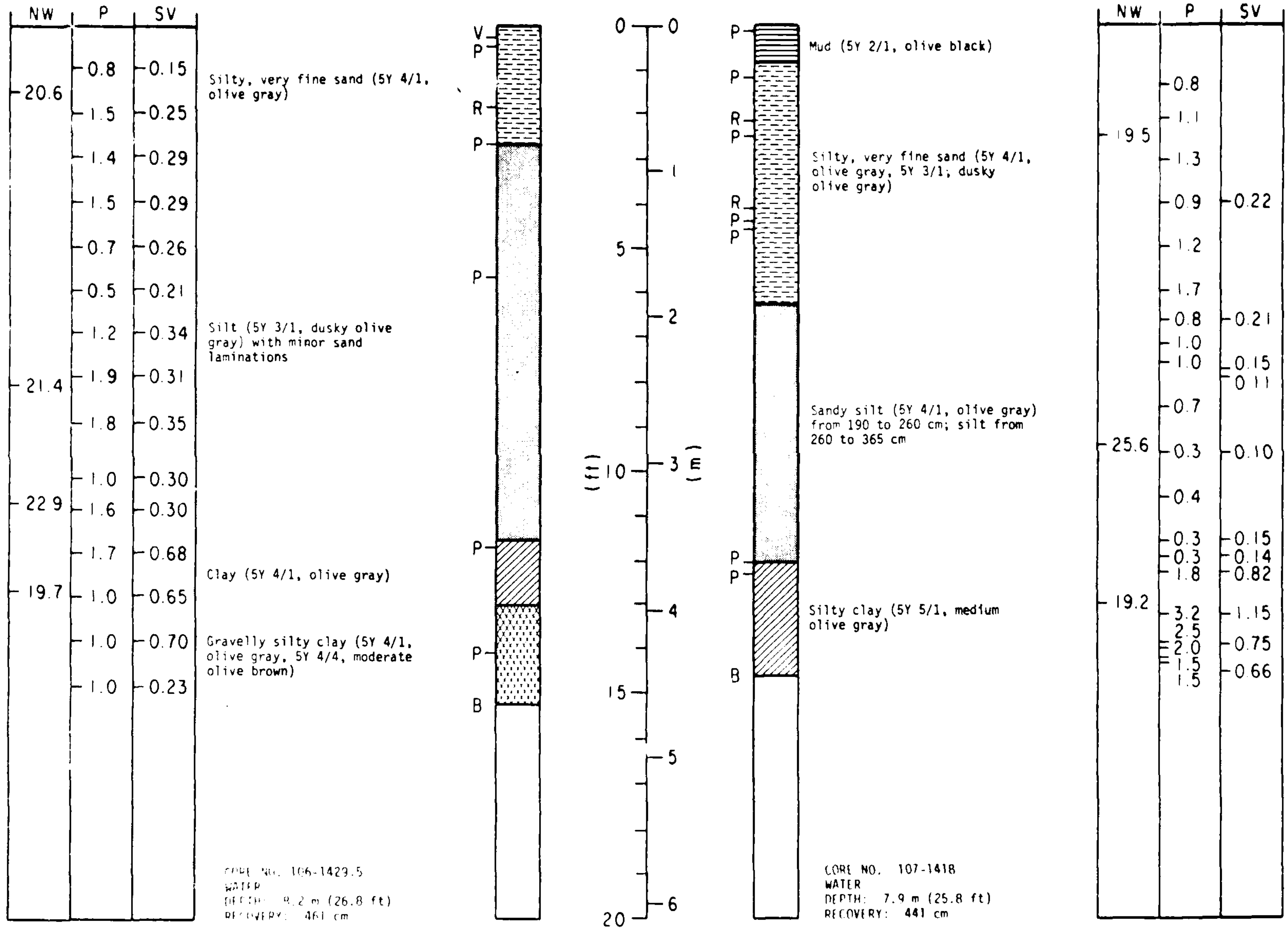

NW
P
SV
37.9
37.0
21.2
21.7
15.2
0.0
0.0
0.0
0.0
0.7
1.4
1.3
0.7
0.9
0.6
0.7
0.6
0.8
2.1
2.2
0.02
0.04
0.05
0.26
0.40
0.28
0.33
0.27
0.25
0.18
0.34
0.65
Sandy silt (5Y 3/2, olive gray)
Silty clay (5Y 4/2, moderate olive gray)
Gravelly silty clay (10YR 5/1, medium yellowish gray)
CORE NO. 98-8.5
WATER
DEPTH: 12.6 m (41.5 ft)
RECOVERY: 333 cm
P
P
P
P
B
0
5
10
15
20
(ft)
0
1
2
3
4
5
6
(m)
P
P
P
P
B
Clayey silt (5Y 3/1, dusky olive gray)
Silty clay (5Y 4/2, moderate brownish gray)
Sandy gravelly clay (5Y 4/1, olive gray)
CORE NO. 99-1172.3
WATER
DEPTH: 12.2 m (39.9 ft)
RECOVERY: 347 cm
NW
P
SV
43.5
31.5
28.0
18.1
12.1
0.0
0.0
0.0
0.2
0.3
0.7
0.7
0.7
1.9
0.6
0.3
2.3
4.4
>4.5
0.5
2.3
0.04
0.05
0.05
0.19
0.16
0.11
0.20
0.35
0.54
0.44
0.20
0.74
1.13
0.11
0.75


NW
P
SV
25.9
25.1
25.0
18.9
19.4
22.0
0.3
0.3
0.4
0.6
0.7
0.7
0.9
0.8
1.0
1.2
1.6
2.2
1.3
0.4
0.8
0.7
0.3
0.4
0.11
0.22
0.28
0.34
0.26
0.31
0.73
0.39
0.40
Sandy silt (5Y 4/2, moderate olive gray)
Silty clay (5Y 5/1, medium brownish gray)
Gravelly clay (5Y 4/2, moderate brownish gray)
Silty clay (5Y 4/1, brownish gray)
CORE NO. 100-1193
WATER DEPTH: 8.9 m (29.3 ft)
RECOVERY: 375 cm
B
(ft)
0
5
10
15
20
(m)
0
1
2
3
4
5
6
R
V
V
R
V
R
R
P
Silty very fine sand (5Y 3/2, olive gray); sand is coarser near top
Sandy silt (5Y 4/1, olive gray)
CORE NO. 101-1407
WATER DEPTH: 6.6 m (21.6 ft)
RECOVERY: 612 cm
Silty fine sand (5Y 3/1, dusky olive gray)
Silty clay (10YR 5/1, medium yellowish gray)
NW
P
SV
18.7
20.0
21.0
22.3
22.6
25.3
21.5
19.9
0.7
1.1
0.8
1.8
0.7
1.0
0.8
1.7
0.7
1.0
0.8
1.8
1.2
1.3
0.3
0.5
0.3
0.7
1.9
0.8
1.0
2.7
2.3
0.15
0.20
0.22
0.22
0.20
0.20
0.18
0.17
0.18
0.24
0.30
0.30
0.30
0.20
0.15
0.20
0.17
0.30
0.51
1.30



NW
P
SV
47.5
22.6
27.9
22.3
27.8
22.5
0.0
0.0
0.5
0.8
1.8
1.5
0.3
0.0
1.4
0.6
0.4
0.5
1.3
2.4
3.3
2.2
0.02
0.06
0.15
0.19
0.26
0.21
0.15
0.10
0.28
0.13
0.16
0.20
0.64
1.18
0.65
1.00
Sandy mud (5Y 3/1, dusky olive gray)
Silt (5Y 3/1, dusky olive gray) with sand laminations
Silty clay (2.5Y 4/2, moderate olive gray)
CORE NO. 102-1408.5
WATER
DEPTH: 8.6 m (28.3 ft)
RECOVERY: 430 cm
P
B
V
(ft)
(m)
0
5
10
20
1
2
3
4
6
Fine sand (5Y 4/2, moderate olive gray) with minor mud
Silt (5Y 4/1, olive gray) with minor sand laminations
WATER
27.8
30.0
0.3
1.4
2.2
0.37
0.12
0.15
0.30
0.10
0.14


NW
P
SV
22.3
0.8
0.36
0.7
0.36
0.2
0.15
23.2
0.3
0.3
0.15
0.3
0.0
0.10
0.0
0.10
0.0
0.10
27.9
0.0
0.09
0.0
0.11
19.5
2.1
0.76
2.2
0.85
Silty clay (2.5Y 4/4, moderate olive brown)
Sandy silt (5Y 3/1, dusky olive gray, 5Y 4/1, olive gray) from 60 to 205 cm; clayey silt from 205 to 310 cm
Silty clay (5Y 4/2, moderate olive gray)
CORE NO. 104-1421
WATER
DEPTH: 10.8 m (35.4 ft)
RECOVERY: 356 cm
P
P
P
P
P
P
B
0
5
10
15
20
(ft)
0
1
2
3
4
5
6
(m)
P
P
P
P
P
P
P
B
Mud (5Y 2/1, olive black)
Silty very fine sand (5Y 3/2, olive gray)
Silt with minor sand (5Y 4/2, moderate olive gray, 5Y 4/1, olive gray) from 60 to 270 cm; clayey silt from 270 to 330 cm
Silty clay (5Y 4/1, olive gray)
CORE NO. 105-1420
WATER
DEPTH: 9.8 m (32.1 ft)
RECOVERY: 473 cm
NW
P
SV
25.6
24.7
23.6
25.9
26.8
27.7
0.2
0.5
0.18
0.9
0.69
1.2
2.2
20.7
2.7
3.2
1.15
2.1
1.00
17.9
2.2
2.0
0.93


NW
P
SV
Silty, very fine sand (5Y 4/1, olive gray)
Silt (5Y 3/1, dusky olive gray) with minor sand laminations
Clay (5Y 4/1, olive gray)
Gravelly silty clay (5Y 4/1, olive gray, 5Y 4/4, moderate olive brown)
CORE NO. 106-1429.5
WATER
DEPTH: 8.2 m (26.8 ft)
RECOVERY: 461 cm
(ft)
(m)
Mud (5Y 2/1, olive black)
Silty, very fine sand (5Y 4/1, olive gray, 5Y 3/1, dusky olive gray)
Sandy silt (5Y 4/1, olive gray) from 190 to 260 cm; silt from 260 to 365 cm
Silty clay (5Y 5/1, medium olive gray)
CORE NO. 107-1418
WATER
DEPTH: 7.9 m (25.8 ft)
RECOVERY: 441 cm

APPENDIX B

GRANULOMETRIC DATA AND CUMULATIVE CURVE PLOTS

The samples in this appendix are identified by core number and sample interval below the top of the core. Locations of the samples in each core are shown in Appendix A.

1. Rapid Sand Analyzer (RSA).

Data include the frequency and cumulative percent at 0.5-phi intervals. Also included are median, mean, standard deviation, skewness, and kurtosis for each sample. Experience has shown that grain-size values from RSA analyses are consistent and slightly coarser than results of sieve analyses of identical samples; therefore, empirical relations for converting RSA means and standard deviation to sieve analyses equivalents have been determined. The relationships, developed from RSA and sieve analyses at a 0.25-phi interval are (from Williams, et al., 1979):

Mean: $\bar{X}_{\emptyset}\text{sieve} = 1.0735\ \bar{X}_{\emptyset RSA} + 0.1876$

Standard deviation: $0_{\emptyset}\text{sieve} = 1.4535\ 0_{\emptyset}\text{RSA} - 0.146$

2. Sieve data.

Data include frequency and cumulative percent at 0.5-phi intervals from samples estimated to have gravel percentages over 10 percent.

3. Cumulative Curves.

Sieve data plotted at 0.5-phi intervals.

4 Pipet analysis.

Percentages of sand, silt, and clay are included for each sample.

5. Visual Accumulation Tube (VAT).

Percentages of sand and silt-clay as well as mean grain size are included for each sample.

DISTRIBUTION OF SIZE CLASSES BY FREQUENCY PERCENTAGES (RSA)

REFERENCE CORE NO.	INT (CM)	SIZE CLASS -1.000 2.000	-.500 1.414	1.000 1.000	.500 .707	1.000 .500	1.500 .354	2.000 .250	2.500 .177	3.000 .125	3.500 .088	4.000 .062	PAN PHI PAN MM.	STATISTICAL PARAMETERS MEDIAN PHI	MEDIAN MM.	MEAN PHI	MEAN MM.	S.D. PHI
51	TOP	0.00	0.00	0.00	0.00	0.00	1.31	12.86	13.53	23.59	30.65	18.06	0.00	2.97	.127	2.88	.136	.64
51	20-30	0.00	0.00	.73	1.08	2.55	15.88	13.88	8.30	16.01	24.67	16.90	0.00	2.78	.145	2.53	.173	.96
51	75-80	0.00	1.85	1.93	.70	4.13	6.00	4.83	14.08	24.27	21.84	13.27	7.10	2.87	.137	2.38	.193	1.19
51	120-12	0.00	.33	1.62	2.57	10.92	7.79	7.51	10.05	24.03	20.77	14.39	0.00	2.71	.152	2.41	.188	1.06
51	160-17	0.00	.20	.90	1.71	3.22	5.17	13.36	17.12	32.63	25.65	0.00	0.00	2.63	.162	2.44	.184	.74
51	170-200	0.00	0.00	0.00	0.00	0.00	0.00	34.56	14.92	20.57	18.52	11.43	0.00	2.51	.175	2.51	.175	.73
51	238-245	0.00	0.00	5.73	36.53	33.78	4.06	3.13	3.50	5.01	8.23	0.00	0.00	.58	.669	.93	.525	.96
51	240-260	0.00	0.00	2.84	6.60	17.68	6.68	12.74	16.20	14.35	11.33	11.58	0.00	2.13	.228	2.01	.249	1.14
52	139-141	0.00	1.33	3.45	4.93	2.40	2.49	4.41	6.94	11.96	24.24	37.85	0.00	3.31	.101	2.82	.141	1.22
52	188-190	0.00	.37	1.51	5.99	7.06	6.53	5.78	6.25	8.15	19.17	39.19	0.00	3.25	.105	2.71	.153	1.23
52	213-215	0.00	.41	4.50	7.74	18.19	7.57	10.45	9.76	10.88	13.30	17.21	0.00	2.07	.238	2.02	.247	1.26
52	230-233	0.00	.31	3.22	23.84	30.54	2.42	2.30	3.78	6.97	11.52	15.10	0.00	.74	.598	1.55	.339	1.37
54	50-90	0.00	.78	1.68	1.54	2.00	3.01	3.51	4.27	18.90	41.59	22.72	0.00	3.17	.111	2.92	.132	.90
55	163	0.00	0.00	1.06	.11	1.13	2.42	6.00	10.81	28.53	32.82	17.10	0.00	3.00	.125	2.80	.136	.72
55	226	0.00	.04	.25	1.06	1.24	7.26	7.96	13.52	23.16	29.57	15.93	0.00	2.92	.132	2.74	.149	.80
56	100-125	0.00	.77	4.37	2.33	2.57	4.65	6.08	5.65	19.69	26.71	23.19	0.00	3.00	.125	2.68	.156	1.11
56	208	0.00	0.00	1.55	2.51	11.37	37.19	8.81	4.99	6.60	11.09	15.17	.72	1.45	.366	1.93	.263	1.13
56	220	0.00	1.24	2.78	.19	1.82	1.23	1.83	17.64	29.97	34.83	8.48	0.00	2.91	.133	2.71	.153	.86
56	234	0.00	.07	.68	.74	1.28	2.62	3.80	12.25	25.24	27.94	25.40	0.00	3.06	.120	2.94	.130	.77
57	90-100	0.00	0.00	1.60	5.87	17.57	27.92	15.12	13.09	9.38	9.46	0.00	0.00	1.44	.368	1.61	.327	.86
57	105	0.00	.71	4.17	4.02	4.58	19.96	26.95	18.99	11.76	8.86	0.00	0.00	1.82	.283	1.79	.291	.87
57	160	0.00	0.00	0.00	0.00	0.00	0.00	1.15	29.52	42.83	26.29	.21	0.00	2.73	.151	2.74	.149	.37
58	TOP	0.00	7.74	6.74	4.93	34.80	23.68	7.[illegible]	[illegible]	7.77	0.00	0.00	0.00	.96	.513	1.01	.496	.87
58	40-50	0.00	[illegible]	[illegible]	4.09	23.54	34.76	6.25	3.76	3.81	6.23	8.42	0.00	1.14	.452	1.41	.377	1.11
58	140-150	0.00	0.00	.40	3.39	40.16	19.80	10.21	6.61	5.24	6.37	7.82	0.00	1.11	.465	1.53	.346	1.07
58	240-250	0.00	1.04	1.96	3.45	23.72	33.09	12.61	11.31	9.77	3.05	0.00	0.00	1.25	.420	1.43	.370	.76
58	310-320	0.00	.63	1.90	1.25	3.74	29.37	17.81	19.38	9.55	7.79	8.57	0.00	1.82	.283	1.96	.257	.93
58	430-440	0.00	.53	.58	.22	1.38	.91	4.97	8.73	30.42	42.92	9.34	0.00	3.03	.123	2.89	.135	.66
58	525	0.00	0.00	1.21	.70	.03	.03	3.33	10.19	32.91	42.30	9.30	0.00	3.02	.124	2.92	.132	.60
59	TOP	0.00	0.00	0.00	.71	27.64	28.21	9.07	7.00	11.00	11.95	4.40	0.00	1.32	.400	1.75	.298	.94
59	50-60	0.00	0.00	0.00	0.00	1.35	3.30	3.30	12.94	27.62	35.83	15.67	0.00	3.02	.123	2.92	.132	.63
59	160-170	0.00	.96	1.01	.16	1.42	1.85	3.23	13.62	31.03	42.12	4.61	0.00	2.96	.129	2.79	.145	.71
59	210	0.00	0.00	0.00	0.00	0.00	.41	2.65	9.16	23.16	37.62	27.00	0.00	3.21	.108	3.14	.114	.51
60	TOP	0.00	0.00	1.41	7.29	38.39	30.02	10.21	8.11	4.58	0.00	0.00	0.00	1.04	.488	1.16	.448	.62
60	10	0.00	0.00	2.53	3.69	34.67	28.97	11.23	6.71	6.16	6.06	0.00	0.00	1.13	.456	1.34	.394	.79
60	40-50	0.00	0.00	1.47	3.74	14.23	31.37	20.87	11.44	6.43	8.06	2.40	0.00	1.49	.357	1.66	.317	.84
60	104-105	0.00	.43	5.67	5.98	21.08	27.77	11.51	7.67	5.65	7.36	6.69	0.00	1.24	.424	1.51	.350	1.05
60	170-180	0.00	0.00	2.07	.33	.46	2.28	18.35	29.86	23.42	9.55	11.70	1.96	2.45	.183	2.41	.188	.86
60	310	0.00	0.00	0.00	1.51	.75	1.67	6.35	27.95	37.11	17.67	6.99	0.00	2.66	.159	2.62	.163	.61
60	495	0.00	1.35	1.63	1.27	2.00	4.06	3.66	7.93	21.47	36.12	20.49	0.00	3.09	.118	2.83	.141	.94
61	117-118	0.00	0.00	0.00	1.95	17.24	30.27	16.01	14.46	9.58	10.21	.26	0.00	1.52	.349	1.74	.300	.80
62	48-49	0.00	.37	1.56	3.53	29.17	26.21	10.35	9.94	9.22	9.66	0.00	0.00	1.23	.428	1.53	.347	.89
62	427-428	0.00	2.94	17.86	13.25	10.80	13.42	5.19	3.58	7.61	13.16	12.16	0.00	1.17	.444	1.49	.356	1.45
62	450-460	0.00	1.25	4.10	6.28	31.11	25.65	8.04	4.15	[illegible]	7.75	8.28	0.00	1.13	.458	1.45	.367	1.09
62	463	0.00	[illegible]	1.84	6.18	[illegible]	[illegible]	[illegible]	5.29	[illegible]	6.88	[illegible]	0.00	1.26	.418	1.49	.355	.99
63	TOP	0.00	0.00	1.37	2.99	35.64	31.07	12.20	[illegible]	8.35	1.68	[illegible]	0.00	1.12	.459	1.33	.357	.66
63	10-60	0.00	2.42	3.52	4.84	36.09	19.78	12.61	4.28	3.35	[illegible]	6.72	0.00	1.07	.476	1.38	.383	1.04
63	60-65	0.00	1.91	12.93	2.77	15.84	35.82	14.88	10.53	5.31	0.00	0.00	0.00	1.19	.437	1.16	.446	.81
63	78-80	0.00	2.99	31.04	12.39	11.12	15.68	6.57	3.08	3.51	6.80	6.81	0.00	.78	.582	.97	.511	1.30

DISTRIBUTION OF SIZE CLASSES BY FREQUENCY PERCENTAGES (RSA)--Continued

REFERENCE CORE NO.	INT (CM)	SIZE CLASS -1.000 2.000	-.500 1.414	1.000 1.000	.500 .707	1.000 .500	1.500 .354	2.000 .250	2.500 .177	3.000 .125	3.500 .088	4.000 .062	PAN PHI PAN MM.	STATISTICAL PARAMETERS MEDIAN PHI	MEDIAN MM.	MEAN PHI	MEAN MM.	S.D. PHI
63	98	0.00	0.00	1.59	.41	21.27	38.46	13.05	6.46	4.37	7.05	6.94	0.00	1.26	.417	1.63	.322	.92
64	TOP	0.00	1.76	6.20	7.63	35.47	25.56	10.22	8.77	4.39	0.00	0.00	0.00	.99	.504	1.07	.476	.73
64	25-35	0.00	.21	2.12	5.94	34.95	25.74	11.49	6.86	7.60	5.10	0.00	0.00	1.12	.460	1.31	.403	.81
64	70-75	0.00	0.00	3.20	5.84	41.54	19.86	9.68	4.50	3.72	6.65	5.01	0.00	.99	.502	1.33	.399	.97
64	90-10	0.00	0.00	.76	4.66	31.28	24.97	8.04	6.05	4.33	6.16	10.83	2.88	1.21	.433	1.57	.336	1.1[illegible]
64	20-11	0.00	.47	2.53	3.79	22.39	28.79	16.94	5.86	4.55	7.28	7.40	0.00	1.36	.389	1.60	.331	.9[illegible]
64	122	0.00	.96	2.80	4.79	24.29	29.33	14.85	5.80	5.03	9.36	2.80	0.00	1.27	.415	1.49	.356	.94
67	29-30	0.00	0.00	0.00	1.00	64.06	.92	.39	20.48	7.24	5.91	0.00	0.00	.89	.541	1.34	.394	.86
67	112	0.00	0.00	0.00	.40	20.26	28.60	19.74	9.50	5.93	8.91	6.60	0.00	1.51	.350	1.77	.293	.84
67	167	0.00	0.00	0.00	0.00	0.00	.05	20.01	24.32	25.50	17.67	12.46	0.00	2.59	.166	2.62	.162	.65
68	TOP	0.00	3.10	7.33	4.58	21.43	36.23	17.28	7.66	2.38	0.00	0.00	0.00	1.14	.454	1.12	.461	.73
68	10-12	0.00	7.79	17.14	6.52	15.78	29.41	12.29	7.95	3.13	0.00	0.00	0.00	1.04	.487	.86	.544	.9[illegible]
68	35-40	0.00	3.89	7.72	7.97	25.77	25.13	10.55	4.51	4.76	8.60	1.08	0.00	1.06	.479	1.22	.429	1.02
68	50-52	0.00	.96	2.47	2.84	15.19	38.18	18.47	5.52	3.97	7.06	5.40	0.00	1.37	.386	1.58	.335	.9[illegible]
68	61	0.00	0.00	.85	3.16	8.72	45.40	11.64	6.49	6.59	9.90	7.24	0.00	1.39	.381	1.75	.297	.94
69	30	0.00	2.31	7.34	10.45	29.22	25.19	10.56	7.86	7.01	0.00	0.00	0.00	1.01	.497	1.07	.475	.81
69	110-120	0.00	0.00	.69	5.70	26.60	25.89	14.41	9.01	5.85	6.74	5.12	0.00	1.27	.415	1.56	.339	.92
69	124-125	0.00	0.00	.60	3.41	7.45	32.6[illegible]	22.11	15.73	9.37	[illegible].74	0.00	0.00	1.61	.327	1.74	.30[illegible]	.76
69	205	0.00	1.08	2.04	5.27	14.75	20.25	19.41	14.48	8.10	9.65	4.90	0.00	1.64	.320	1.74	.299	.99
69	364	0.00	.17	1.49	2.24	2.00	3.45	4.48	6.61	26.14	38.15	14.86	0.00	3.04	.122	2.80	.144	.87
76	60	0.00	0.00	.55	1.94	1.15	3.07	3.40	6.26	17.33	30.64	29.66	0.00	3.28	.103	3.02	.123	.79
84	TOP	0.00	.06	2.64	1.73	2.06	9.14	15.12	19.21	38.06	11.98	0.00	0.00	2.50	.177	2.27	.208	.79
84	2-3	0.00	.26	.42	2.02	4.06	18.30	14.21	20.07	28.92	11.74	0.00	0.00	2.28	.205	2.14	.227	.79
84	10-20	0.00	.09	.82	1.01	.62	1.94	8.64	19.82	47.24	19.81	0.00	0.00	2.73	.150	2.57	.168	.60
84	35-36	0.00	1.38	1.37	4.66	1.61	9.62	18.67	24.91	18.42	10.79	8.58	0.00	2.26	.208	2.19	.219	.95
84	70-80	0.00	0.00	0.00	0.00	1.06	1.83	3.64	26.86	22.82	23.12	20.67	0.00	2.83	.141	2.84	.140	.65
84	140-141	0.00	.01	.87	.05	.19	1.01	3.54	10.01	33.67	44.87	5.79	0.00	3.01	.124	2.90	.134	.56
84	205-207	0.00	.94	1.74	5.36	36.02	21.88	11.87	9.17	11.44	1.60	0.00	0.00	1.12	.460	1.34	.396	.80
84	218	0.00	.60	3.41	5.27	19.41	15.66	8.65	8.02	11.69	18.53	8.76	0.00	1.78	.291	1.93	.263	1.16
84	228-229	0.00	.36	.68	.51	2.29	4.68	4.79	7.16	16.06	37.78	25.70	0.00	3.20	.109	2.93	.131	.82
84	260-270	0.00	0.00	.95	1.30	1.38	2.75	3.66	8.40	17.97	39.17	23.83	0.00	3.19	.109	2.95	.129	.79
84	291-292	0.00	0.00	0.00	0.00	0.00	1.30	16.56	23.62	19.36	21.54	17.60	0.00	2.68	.156	2.74	.149	.66
85	387-388	0.00	0.00	0.00	0.00	0.00	.85	1.65	17.50	34.32	31.43	14.56	0.00	2.95	.129	2.95	.129	.48
87	30-80	0.00	8.90	18.66	16.02	6.50	4.00	7.37	9.68	9.73	8.38	10.76	0.00	.99	.504	1.33	.399	1.50
87	82-83	0.00	2.25	7.30	8.93	8.39	12.23	12.82	15.02	11.71	9.70	11.63	0.00	1.90	.269	1.84	.279	1.23
87	370	0.00	.66	2.22	2.08	1.03	1.64	3.83	6.23	13.46	37.89	30.56	0.00	3.27	.103	2.96	.128	.93
89	TOP	0.00	0.00	.31	2.35	7.40	37.68	27.50	19.85	4.92	0.00	0.00	0.00	1.55	.343	1.60	.331	.54
89	30-40	0.00	0.00	0.00	0.00	3.56	37.75	32.87	19.50	6.32	0.00	0.00	0.00	1.62	.325	1.70	.307	.45
89	35-36	0.00	1.38	3.17	.08	1.35	40.23	22.05	21.71	10.02	0.00	0.00	0.00	1.62	.326	1.65	.319	.69
89	60-61	0.00	0.00	2.82	4.44	9.47	38.29	24.79	14.61	5.58	0.00	0.00	0.00	1.45	.367	1.47	.361	.63
89	90-100	0.00	0.00	0.00	0.00	5.29	27.46	32.48	19.94	7.11	7.72	0.00	0.00	1.74	.298	1.85	.277	.63
89	126-127	0.00	.23	2.83	6.06	24.57	27.04	14.82	6.9[illegible]	[illegible]	6.21	7.08	0.00	1.27	.414	1.52	.348	1.00
89	170-190	0.00	0.00	[illegible]	1.68	7.46	24.4[illegible]	28.[illegible]	15.68	5.56	7.48	8.85	0.00	1.77	.294	1.95	.259	.85
89	202-205	0.00	1.12	6.2[illegible]	7.96	20.26	20.14	16.62	10.91	9.26	1.53	0.00	0.00	1.18	.442	1.24	.406	.85
89	277-278	0.00	1.41	3.04	2.41	20.90	27.60	17.09	12.36	7.37	7.42	0.00	0.00	1.39	.381	1.51	.350	.87
90	TOP	0.00	0.00	0.00	.98	4.16	11.38	39.25	26.94	13.54	3.74	0.00	0.00	1.89	.270	1.95	.259	.57
90	10-20	0.00	3.76	8.30	.63	3.79	16.06	27.76	26.70	13.01	0.00	0.00	0.00	1.79	.288	1.63	.324	.92
90	100-107	0.00	6.16	60.91	21.01	2.57	2.51	6.84	0.00	0.00	0.00	0.00	0.00	-.11	1.080	.04	.974	.58
90	111-112	0.00	0.00	5.37	20.89	7.37	1.66	25.37	19.75	12.19	7.40	0.00	0.00	1.76	.294	1.56	.340	1.04
90	149-150	0.00	11.68	8.14	8.55	5.11	14.54	16.19	15.68	5.31	5.23	9.57	0.00	1.56	.340	1.46	.365	1.34
90	200-210	0.00	0.00	0.00	0.00	0.00	1.11	39.83	29.41	14.07	7.23	8.35	0.00	2.17	.222	2.30	.203	.64
90	210-2[illegible]	0.00	0.00	0.00	0.00	0.00	9.30	30.12	34.97	16.54	9.07	0.00	0.00	2.15	.225	2.16	.221	.53
90	238-2[illegible]	0.00	0.00	0.00	0.00	0.00	.48	25.08	42.41	18.60	9.24	4.19	0.00	2.28	.206	2.37	.193	.51

DISTRIBUTION OF SIZE CLASSES BY FREQUENCY PERCENTAGES (RSA)--Continued

REFERENCE CORE NO.	INT (CM)	-1.000 2.000	-.500 1.414	1.000 1.000	.500 .707	1.000 .500	1.500 .354	2.000 .250	2.500 .177	3.000 .125	3.500 .088	4.000 .062	PAN PAN	PHI MM.	MEDIAN PHI	MEDIAN MM.	MEAN PHI	MEAN MM.	S.D. PHI
90	274-275	0.00	0.00	0.00	0.00	0.00	.87	31.78	37.86	13.20	6.50	9.80	0.00		2.19	.219	2.37	.194	.61
90	305-306	0.00	.44	1.68	.98	.76	1.24	31.44	31.26	15.65	7.62	8.93	0.00		2.21	.216	2.28	.206	.77
90	310-320	0.00	0.00	0.00	0.00	0.00	6.89	17.28	28.87	21.17	11.45	14.34	0.00		2.45	.183	2.53	.173	.72
90	369-371	0.00	5.30	10.78	24.89	15.63	13.13	9.14	2.72	4.77	5.72	7.91	0.00		.78	.584	1.11	.464	1.27
91	32-33	0.00	.42	.63	.34	1.15	3.50	32.08	32.84	15.69	5.54	7.80	0.00		2.19	.219	2.23	.213	.72
92	0-10	0.00	.12	1.09	1.10	1.81	2.09	16.67	43.42	33.68	0.00	0.00	0.00		2.32	.200	2.24	.211	.54
92	65-66	0.00	0.00	0.00	0.00	0.00	1.20	.97	40.56	39.16	9.56	8.55	0.00		2.57	.168	2.64	.160	.47
93	TOP	0.00	0.00	0.00	0.00	.56	1.05	28.55	32.89	21.22	6.49	9.23	0.00		2.33	.198	2.40	.189	.63
93	10-11	0.00	0.00	0.00	0.00	1.39	2.65	21.65	43.83	26.18	4.12	0.00	0.00		2.27	.207	2.27	.207	.43
93	40-50	0.00	1.47	2.59	1.11	1.36	1.43	22.99	34.97	30.08	0.00	0.00	0.00		2.27	.207	2.14	.227	.69
93	100-101	0.00	1.13	5.23	1.85	3.35	2.53	23.13	31.74	27.23	3.81	0.00	0.00		2.23	.213	2.05	.242	.84
93	140-150	0.00	0.00	0.00	0.00	0.00	1.00	10.32	50.17	24.03	11.74	2.75	0.00		2.38	.192	2.46	.181	.47
93	200-201	0.00	0.00	.90	.62	.84	8.14	23.70	25.65	23.09	7.42	9.44	0.00		2.33	.199	2.34	.197	.75
93	210-220	0.00	.26	.92	1.39	2.34	5.33	11.85	29.90	34.10	11.10	2.81	0.00		2.47	.180	2.37	.193	.71
93	227-228	0.00	0.00	0.00	.04	.82	1.34	17.14	25.51	37.64	9.40	8.11	0.00		2.56	.169	2.55	.171	.58
93	235-236	0.00	4.35	11.10	5.76	9.49	10.88	13.79	10.45	16.44	14.17	3.07	0.00		1.79	.289	1.69	.311	1.25
93	245-246	0.00	0.00	0.00	.29	2.28	5.46	23.02	24.53	27.74	9.64	7.05	0.00		2.39	.191	2.38	.192	.64
94	TOP	0.00	0.00	.46	1.77	3.23	18.24	30.94	29.37	9.15	6.85	0.00	0.00		1.90	.267	1.94	.261	.63
94	9-10	0.00	0.00	0.00	0.00	2.11	29.27	28.27	22.93	8.56	8.86	0.00	0.00		1.84	.280	1.90	.267	.64
94	20-30	0.00	0.00	2.55	6.01	6.29	27.45	23.48	17.74	9.64	6.83	0.00	0.00		1.64	.321	1.70	.308	.79
94	34-35	0.00	11.60	23.15	11.19	7.60	16.73	9.23	9.53	6.17	2.81	0.00	0.00		.77	.585	.84	.560	1.16
94	46-47	0.00	2.25	6.33	24.41	19.22	16.18	12.82	8.44	7.15	3.01	0.00	0.00		.93	.524	1.08	.471	.94
94	50-60	0.00	.97	8.52	16.95	17.51	17.54	12.92	9.49	7.01	9.09	0.00	0.00		1.19	.438	1.30	.407	1.04
94	70-80	0.00	0.00	0.00	.85	1.77	21.88	44.39	21.28	9.83	0.00	0.00	0.00		1.72	.304	1.81	.285	.45
94	80-90	0.00	0.00	0.00	0.00	1.12	29.06	35.46	20.23	8.45	5.69	0.00	0.00		1.71	.306	1.85	.277	.56
94	100-102	0.00	2.10	20.10	16.33	2.06	18.64	13.91	13.27	9.86	3.73	0.00	0.00		1.35	.393	1.17	.443	1.1[illegible]
94	120-130	0.00	.43	2.21	1.81	1.52	4.67	29.00	25.29	19.12	8.61	7.34	0.00		2.25	.210	2.21	.216	.83
94	130-140	0.00	0.00	0.00	1.53	1.31	15.59	17.24	30.13	17.17	9.04	7.99	0.00		2.25	.210	2.26	.208	.75
94	143	0.00	0.00	0.00	0.00	.55	2.43	24.10	31.89	21.46	9.49	10.09	0.00		2.37	.194	2.43	.185	.67
97	TOP	0.00	0.00	7.22	11.38	17.55	15.41	13.40	15.05	13.39	6.61	0.00	0.00		1.45	.365	1.49	.357	.99
97	20-30	0.00	.53	6.08	9.67	9.49	6.26	17.48	19.00	15.22	8.01	8.27	0.00		2.01	.248	1.88	.272	1.13
97	40-41	0.00	.94	11.10	5.02	4.14	3.66	14.32	16.52	21.25	10.01	13.11	0.00		2.39	.191	2.09	.235	1.26
101	35-45	0.00	0.00	0.00	0.00	.10	1.10	2.70	17.04	23.54	30.88	24.00	0.00		3.06	.118	3.01	.124	.59
101	140-150	0.00	0.00	.14	2.02	1.37	2.26	5.20	9.77	21.14	45.26	12.86	0.00		3.10	.117	2.88	.136	.73
101	260-270	0.00	0.00	0.00	.36	1.42	2.07	3.79	5.68	18.60	37.43	30.65	0.00		3.27	.103	3.09	.117	.65
101	501-533	0.00	1.13	2.30	1.82	.93	2.54	1.37	16.16	28.59	28.36	16.78	0.00		2.93	.132	2.75	.149	.92
106	50-60	0.00	0.00	.84	.47	.02	.01	2.19	4.14	22.10	39.73	30.52	0.00		3.28	.103	3.17	.111	.59
107	60-70	0.00	0.00	0.00	0.00	0.00	0.00	1.76	11.96	20.27	35.53	30.48	0.00		3.25	.105	3.16	.112	.51
107	120-130	0.00	.20	.60	.36	1.52	.77	2.14	4.76	27.14	32.73	29.78	0.00		3.20	.109	3.09	.118	.69

CERC SEDIMENT ANALYSIS

CERC C# 0051 Collected by ______ Date May 1979
Project ICONS LAKE ERIE - OHIO
Location/Sample No. ERIE, PA
Remarks CORE 51 80 - 105 cm

SIEVE ANALYSIS OF SAND

Weight of Sample 340.41 gr. Analyzed by ______ Date ______

φ	Screen Opening MM	U.S. Mesh Number	Retained on Sieves: Grams	Retained on Sieves: Per Cent	Retained on Sieves: Cumulative Per Cent	Cumulative Per Cent Passing
-6.67	26.670	1 3/64				
-5.60	22.400	7/8				
-4.80	19.200	3/4				
-4.00	16.000	5/8				
-3.68	13.550	1/2	19.82	5.87	5.87	
-3.50	11.100	7/16	3.90	1.16	7.03	
-3.25	9.520	3/8	3.70	1.09	8.13	
-3.00	7.930	5/16	2.00	0.59	8.72	
-2.65	6.350	1/4	1.20	0.36	9.08	
-2.50	5.613	3 1/2	1.12	0.33	9.41	
-2.25	4.760	4				
-2.00	3.962	5	4.90	1.45	10.86	
-1.75	3.360	6				
-1.50	2.794	7	3.60	1.07	11.93	
-1.25	2.362	8				
-1.00	2.000	10	2.60	0.77	12.70	
-0.75	1.700	12				
-0.50	1.400	14	2.39	0.71	13.41	
-0.25	1.180	16				
0.00	1.000	18	3.40	1.00	14.41	
+0.25	.850	20				
+0.50	.710	25	7.32	2.17	16.58	
+0.75	.600	30				
+1.00	.500	35	17.43	5.17	21.75	
+1.25	.425	40				
+1.50	.355	45	29.59	8.77	30.52	
+1.75	.300	50				
+2.00	.250	60	27.35	8.11	38.63	
+2.25	.212	70				
+2.50	.180	80	14.75	4.37	43.00	
+2.75	.150	100				
+3.00	.125	120	36.10	10.70	53.70	
+3.25	.106	140				
+3.50	.090	170	88.35	26.19	79.88	
+3.75	.075	200				
+4.00	.063	230	27.88	8.26	88.15	
	0.000	Pan	39.99	11.85	100.00	
	Totals		337.39			
	Gain or loss		-3.02			

CERC SEDIMENT ANALYSIS

CERC C# 0052 Collected by ______ Date May 1979
Project ICONS LAKE ERIE - OHIO
Location/Sample No. ______
Remarks CORE 52 76-77 cm

SIEVE ANALYSIS OF SAND

Weight of Sample 70.05 gr. Analyzed by ______ Date ______

φ	Screen Opening MM	U.S. Mesh Number	Retained on Sieves: Grams	Retained on Sieves: Per Cent	Retained on Sieves: Cumulative Per Cent	Cumulative Per Cent Passing
-6.67	26.670	1 3/64				
-5.60	22.400	7/8				
-4.80	19.200	3/4				
-4.00	16.000	5/8				
-3.68	13.550	1/2				
-3.50	11.100	7/16				
-3.25	9.520	3/8	1.63	2.38	2.38	
-3.00	7.930	5/16				
-2.65	6.350	1/4	1.35	1.97	4.35	
-2.50	5.613	3 1/2	1.25	1.82	6.17	
-2.25	4.760	4				
-2.00	3.962	5	1.81	2.64	8.81	
-1.75	3.360	6				
-1.50	2.794	7	4.61	6.72	15.53	
-1.25	2.362	8				
-1.00	2.000	10	5.11	7.45	22.98	
-0.75	1.700	12				
-0.50	1.400	14	7.29	10.63	33.62	
-0.25	1.180	16				
0.00	1.000	18	6.72	9.80	43.42	
+0.25	.850	20				
+0.50	.710	25	6.79	9.90	53.32	
+0.75	.600	30				
+1.00	.500	35	9.88	14.40	67.73	
+1.25	.425	40				
+1.50	.355	45	6.30	9.19	76.91	
+1.75	.300	50				
+2.00	.250	60	2.90	4.23	81.14	
+2.25	.212	70				
+2.50	.180	80	0.31	0.45	81.60	
+2.75	.150	100				
+3.00	.125	120	0.22	0.32	81.92	
+3.25	.106	140				
+3.50	.090	170	2.00	2.92	84.83	
+3.75	.075	200				
+4.00	.063	230	5.90	8.60	93.44	
	0.000	Pan	4.50	6.56	100.00	
	Totals		68.57			
	Gain or loss		-1.48			

CERC SEDIMENT ANALYSIS

CERC C# 0055 Collected by ______ Date May 1979
Project ICONS LAKE ERIE - OHIO
Location/Sample No. ______
Remarks CORE 56 257 - 260 cm

SIEVE ANALYSIS OF SAND

Weight of Sample 114.60 gr. Analyzed by ______ Date ______

φ	Screen Opening MM	U.S. Mesh Number	Retained on Sieves Grams	Per Cent	Cumulative Per Cent	Cumulative Per Cent Passing
-6.67	26.670	1 3/64				
-5.60	22.400	7/8				
-4.80	19.200	3/4				
-4.00	16.000	5/8				
-3.65	13.550	1/2	5.95	5.21	5.21	
-3.50	11.100	7/16	4.31	3.77	8.98	
-3.25	9.520	3/8	8.24	7.21	16.20	
-3.00	7.930	5/16	10.80	9.45	25.65	
-2.65	6.350	1/4	12.69	11.11	36.76	
-2.50	5.613	3 1/2	7.15	6.26	43.02	
-2.25	4.760	4				
-2.00	3.962	5	10.82	9.47	52.49	
-1.75	3.360	6				
-1.50	2.794	7	11.70	10.24	62.73	
-1.25	2.362	8				
-1.00	2.000	10	6.52	5.70	68.44	
-0.75	1.700	12				
-0.50	1.400	14	5.53	4.84	73.28	
-0.25	1.180	16				
0.00	1.000	18	4.22	3.69	76.98	
+0.25	.850	20				
+0.50	.710	25	3.60	3.15	80.13	
+0.75	.600	30				
+1.00	.500	35	3.02	2.64	82.77	
+1.25	.425	40				
+1.50	.355	45	1.69	1.48	84.25	
+1.75	.300	50				
+2.00	.250	60	1.10	0.96	85.21	
+2.25	.212	70				
+2.50	.180	80	0.98	0.86	86.07	
+2.75	.150	100				
+3.00	.135	120	2.69	2.35	88.43	
+3.25	.106	140				
+3.50	.090	170	5.52	4.83	93.26	
+3.75	.075	200				
+4.00	.063	230	2.99	2.62	95.88	
	0.000	Pan	4.71	4.12	100.00	
	Totals		114.23			
	Gain or loss		-.37			

CERC SEDIMENT ANALYSIS

CERC C# 0058 Collected by ______ Date May 1979
Project ICONS LAKE ERIE - OHIO
Location/Sample No. ______
Remarks CORE 58 25 cm

SIEVE ANALYSIS OF SAND

Weight of Sample 129.99 gr. Analyzed by ______ Date ______

φ	Screen Opening MM	U.S. Mesh Number	Retained on Sieves Grams	Per Cent	Cumulative Per Cent	Cumulative Per Cent Passing
-6.67	26.670	1 3/64				
-5.60	22.400	7/8				
-4.80	19.200	3/4				
-4.00	16.000	5/8				
-3.68	13.550	1/2				
-3.50	11.100	7/16				
-3.25	9.520	3/8				
-3.00	7.930	5/16	1.21	0.94	0.94	
-2.65	6.350	1/4	1.48	1.15	2.09	
-2.50	5.613	3 1/2	1.42	1.10	3.20	
-2.25	4.760	4	—			
-2.00	3.962	5	11.59	9.01	12.21	
-1.75	3.360	6				
-1.50	2.794	7	18.70	14.54	26.74	
-1.25	2.362	8				
-1.00	2.000	10	10.70	8.31	35.06	
-0.75	1.700	12				
-0.50	1.400	14	7.02	5.46	40.52	
-0.25	1.180	16				
0.00	1.000	18	4.75	3.69	44.21	
+0.25	.850	20				
+0.50	.710	25	5.79	4.50	48.71	
+0.75	.600	30				
+1.00	.500	35	13.52	10.51	59.22	
+1.25	.425	40				
+1.50	.355	45	29.70	23.09	82.31	
+1.75	.300	50				
+2.00	.250	60	15.90	12.36	94.67	
+2.25	.212	70				
+2.50	.180	80	3.79	2.95	97.62	
+2.75	.150	100				
+3.00	.135	120	1.90	1.48	99.10	
+3.25	.106	140				
+3.50	.090	170	0.73	0.57	99.67	
+3.75	.075	200				
+4.00	.063	230	0.22	0.17	99.84	
	0.000	Pan	0.21	0.16	100.00	
	Totals		128.63			
	Gain or loss		-1.36			

CERC SEDIMENT ANALYSIS

CERC C# 0071 Collected by________ Date May 1979

Project ICONS LAKE ERIE - OHIO

Location/Sample No.________

Remarks CORE 71 0 - 7 cm

SIEVE ANALYSIS OF SAND

Weight of Sample 188.62 gr. Analyzed by________ * Date________

Φ	Screen Opening MM	U.S. Mesh Number	Retained on Sieves: Grams	Per Cent	Cumulative Per Cent	Cumulative Per Cent Passing
-6.67	26.670	1 3/64				
-5.60	22.400	7/8				
-4.80	19.200	3/4	8.30	4.42	4.42	
-4.00	16.000	5/8	24.18	12.87	17.29	
-3.68	13.550	1/2	5.48	2.92	20.21	
-3.50	11.100	7/16	8.88	4.73	24.93	
-3.25	9.520	3/8	9.71	5.17	30.10	
-3.00	7.930	5/16	8.64	4.60	34.70	
-2.65	6.350	1/4	4.73	2.52	37.22	
-2.50	5.613	3 1/2	3.70	1.97	39.19	
-2.25	4.760	4				
-2.00	3.962	5	5.43	2.89	42.08	
-1.75	3.360	6				
-1.50	2.794	7	3.50	1.86	43.94	
-1.25	2.362	8				
-1.00	2.000	10	3.65	1.94	45.89	
-0.75	1.700	12				
-0.50	1.400	14	3.80	2.02	47.91	
-0.25	1.180	16				
0.00	1.000	18	7.39	3.93	51.84	
+0.25	.850	20				
+0.50	.710	25	18.99	10.11	61.95	
+0.75	.600	30				
+1.00	.500	35	23.32	12.41	74.37	
+1.25	.425	40				
+1.50	.355	45	16.30	8.68	83.04	
+1.75	.300	50				
+2.00	.250	60	14.32	7.62	90.67	
+2.25	.212	70				
+2.50	.180	80	11.01	5.86	96.53	
+2.75	.150	100				
+3.00	.125	120	3.62	1.93	98.46	
+3.25	.106	140				
+3.50	.090	170	1.00	0.53	98.99	
+3.75	.075	200				
+4.00	.063	230	0.50	0.27	99.25	
	0.000	Pan	1.40	0.75	100.00	
	Totals		187.85			
	Gain or loss		-.77			

CERC SEDIMENT ANALYSIS

CERC C# 0087 Collected by________ Date May 1979

Project ICONS LAKE ERIE - OHIO

Location/Sample No. ERIE, PA

Remarks CORE 87 31 - 34 cm

SIEVE ANALYSIS OF SAND

Weight of Sample 118.51 gr. Analyzed by________ * Date________

Φ	Screen Opening MM	U.S. Mesh Number	Retained on Sieves: Grams	Per Cent	Cumulative Per Cent	Cumulative Per Cent Passing
-6.67	26.670	1 3/64				
-5.60	22.400	7/8				
-4.80	19.200	3/4				
-4.00	16.000	5/8				
-3.68	13.550	1/2				
-3.50	11.100	7/16				
-3.25	9.520	3/8				
-3.00	7.930	5/16	1.90	1.61	1.61	
-2.65	6.350	1/4	1.20	1.02	2.63	
-2.50	5.613	3 1/2	2.23	1.89	4.52	
-2.25	4.760	4				
-2.00	3.962	5	6.32	5.36	9.88	
-1.75	3.360	6				
-1.50	2.794	7	8.05	6.82	16.71	
-1.25	2.362	8				
-1.00	2.000	10	11.32	9.60	26.31	
-0.75	1.700	12				
-0.50	1.400	14	18.62	15.79	42.10	
-0.25	1.180	16				
0.00	1.000	18	21.52	18.25	60.35	
+0.25	.850	20				
+0.50	.710	25	16.60	14.08	74.42	
+0.75	.600	30				
+1.00	.500	35	8.72	7.39	81.82	
+1.25	.425	40				
+1.50	.355	45	3.58	3.04	84.85	
+1.75	.300	50				
+2.00	.250	60	4.29	3.64	88.49	
+2.25	.212	70				
+2.50	.180	80	4.59	3.89	92.38	
+2.75	.150	100				
+3.00	.125	120	6.00	5.09	97.47	
+3.25	.106	140				
+3.50	.090	170	1.60	1.36	98.83	
+3.75	.075	200				
+4.00	.063	230	0.39	0.33	99.16	
	0.000	Pan	0.99	0.84	100.00	
	Totals		117.92			
	Gain or loss		-0.59			

CERC SEDIMENT ANALYSIS

CERC CN 0087 Collected by ______ Date May 1979
Project ICONS LAKE ERIE - OHIO
Location/Sample No. ______
Remarks CORE 87 50 - 54 cm

SIEVE ANALYSIS OF SAND

Weight of Sample 191.80 gr. Analyzed by ______ Date ______

Φ	Screen Opening MM	U.S. Mesh Number	Retained on Sieves: Grams	Retained on Sieves: Per Cent	Retained on Sieves: Cumulative Per Cent	Cumulative Per Cent Passing
-6.67	26.670	1 3/64				
-5.60	22.400	7/8				
-4.80	19.200	3/4				
-4.00	16.000	5/8				
-3.58	13.550	1/2	6.90	3.64	3.64	
-3.50	11.100	7/16	—			
-3.25	9.520	3/8	1.60	0.84	4.48	
-3.00	7.930	5/16	—			
-2.65	6.350	1/4	5.48	2.89	7.36	
-2.50	5.613	3 1/2	2.50	1.32	8.68	
-2.25	4.760	4	—			
-2.00	3.962	5	12.22	6.44	15.12	
-1.75	3.360	6				
-1.50	2.794	7	14.49	7.64	22.75	
-1.25	2.362	8				
-1.00	2.000	10	16.59	8.74	31.49	
-0.75	1.700	12				
-0.50	1.400	14	27.05	14.25	45.74	
-0.25	1.180	16				
0.00	1.000	18	32.99	17.38	63.12	
+0.25	.850	20				
+0.50	.710	25	26.00	13.70	76.82	
+0.75	.600	30				
+1.00	.500	35	12.70	6.69	83.51	
+1.25	.425	40				
+1.50	.355	45	3.90	2.05	85.57	
+1.75	.300	50				
+2.00	.250	60	4.10	2.16	87.73	
+2.25	.212	70				
+2.50	.180	80	5.12	2.70	90.42	
+2.75	.150	100				
+3.00	.125	120	6.09	3.20	93.63	
+3.25	.106	140				
+3.50	.090	170	3.29	1.73	95.36	
+3.75	.075	200				
+4.00	.063	230	4.30	2.27	97.63	
	0.000	Pan	4.50	2.37	100.00	
	Totals		189.82			
	Gain or loss		-1.98			

CERC SEDIMENT ANALYSIS

CERC CN 0090 Collected by ______ Date May 1979
Project ICONS LAKE ERIE - OHIO
Location/Sample No. ______
Remarks CORE 90 30 - 35 cm

SIEVE ANALYSIS OF SAND

Weight of Sample 119.25 gr. Analyzed by ______ Date ______

Φ	Screen Opening MM	U.S. Mesh Number	Retained on Sieves: Grams	Retained on Sieves: Per Cent	Retained on Sieves: Cumulative Per Cent	Cumulative Per Cent Passing
-6.67	26.670	1 3/64				
-5.60	22.400	7/8				
-4.80	19.200	3/4	10.89	9.17	9.17	
-4.00	16.000	5/8	5.49	4.62	13.79	
-3.58	13.550	1/2	7.40	6.23	20.01	
-3.50	11.100	7/16				
-3.25	9.520	3/8	2.50	2.10	22.12	
-3.00	7.930	5/16	6.31	5.31	27.43	
-2.65	6.350	1/4	7.11	5.98	33.41	
-2.50	5.613	3 1/2	1.68	1.41	34.83	
-2.25	4.760	4				
-2.00	3.962	5	11.70	9.84	44.67	
-1.75	3.360	6				
-1.50	2.794	7	7.70	6.48	51.15	
-1.25	2.362	8				
-1.00	2.000	10	7.61	6.40	57.56	
-0.75	1.700	12				
-0.50	1.400	14	9.69	8.16	65.71	
-0.25	1.180	16				
0.00	1.000	18	9.00	7.57	73.29	
+0.25	.850	20				
+0.50	.710	25	5.47	4.60	77.89	
+0.75	.600	30				
+1.00	.500	35	2.10	1.77	79.66	
+1.25	.425	40				
+1.50	.355	45	1.15	0.97	80.63	
+1.75	.300	50				
+2.00	.250	60	3.60	3.03	83.66	
+2.25	.212	70				
+2.50	.180	80	10.00	8.42	92.07	
+2.75	.150	100				
+3.00	.125	120	7.72	6.50	98.57	
+3.25	.106	140				
+3.50	.090	170	1.00	0.84	99.41	
+3.75	.075	200				
+4.00	.063	230	0.20	0.17	99.58	
	0.000	Pan	0.50			
	Totals		118.82			
	Gain or loss		-.43			

CERC SEDIMENT ANALYSIS

CERC CN 0090 Collected by ______ Date May 1979
Project ICONS LAKE ERIE - OHIO
Location/Sample No. ______
Remarks CORE 90 50 - 60 cm

SIEVE ANALYSIS OF SAND

Weight of Sample 160.69 gr. Analyzed by ______ Date ______

φ	Screen Opening MM	U.S. Mesh Number	Retained on Sieves: Grams	Retained on Sieves: Per Cent	Retained on Sieves: Cumulative Per Cent	Cumulative Per Cent Passing
-6.67	26.670	1 3/64				
-5.60	22.400	7/8				
-4.80	19.200	3/4				
-4.00	16.000	5/8				
-3.68	13.550	1/2				
-3.50	11.100	7/16				
-3.25	9.520	3/8	1.45	0.91	0.91	
-3.00	7.930	5/16				
-2.65	6.350	1/4	4.10	2.57	3.48	
-2.50	5.613	3 1/2	3.10	1.94	5.42	
-2.25	4.760	4				
-2.00	3.962	5	14.00	8.[illegible]	14.18	
-1.75	3.360	6				
-1.50	2.794	7	23.51	14.72	28.90	
-1.25	2.362	8				
-1.00	2.000	10	25.65	16.06	44.97	
-0.75	1.700	12				
-0.50	1.400	14	31.45	19.70	64.66	
-0.25	1.180	16				
0.00	1.000	18	23.90	14.97	79.62	
+0.25	.850	20				
+0.50	.710	25	10.11	6.33	85.95	
+0.75	.600	30				
+1.00	.500	35	1.69	1.05	87.01	
+1.25	.425	40				
+1.50	.355	45	0.55	0.34	87.36	
+1.75	.300	50				
+2.00	.250	60	2.08	1.30	88.66	
+2.25	.212	70				
+2.50	.180	80	8.50	5.32	93.98	
+2.75	.150	100				
+3.00	.125	120	1.00	0.63	94.61	
+3.25	.106	1-0				
+3.50	.090	170	7.32	4.58	99.19	
+3.75	.075	200				
+4.00	.063	230	0.37	0.23	99.42	
	0.000	Pan	1.00	0.63	100.05	
	Totals		159.70			
	Gain or loss		-.91			

CERC SEDIMENT ANALYSIS

CERC CN 0090 Collected by ______ Date May 1979
Project ICONS LAKE ERIE - OHIO
Location/Sample No. ______
Remarks CORE 90 75 - 80

SIEVE ANALYSIS OF SAND

Weight of Sample 142.10 gr. Analyzed by ______ Date ______

φ	Screen Opening MM	U.S. Mesh Number	Retained on Sieves: Grams	Retained on Sieves: Per Cent	Retained on Sieves: Cumulative Per Cent	Cumulative Per Cent Passing
-6.67	26.670	1 3/64				
-5.60	22.400	7/8				
-4.80	19.200	3/4				
-4.00	16.000	5/8				
-3.68	13.550	1/2				
-3.50	11.100	7/16				
-3.25	9.520	3/8				
-3.00	7.930	5/16	1.00	0.71	0.71	
-2.65	6.350	1/4	2.31	1.63	2.34	
-2.50	5.613	3 1/2	3.70	2.61	4.96	
-2.25	4.760	4				
-2.00	3.962	5	16.50	11.67	16.63	
-1.75	3.360	6				
-1.50	2.794	7	27.05	19.13	35.75	
-1.25	2.362	8				
-1.00	2.000	10	26.02	18.40	54.15	
-0.75	1.700	12				
-0.50	1.400	14	31.18	22.05	76.20	
-0.25	1.150	16				
0.00	1.000	18	20.90	14.78	90.98	
+0.25	.850	20				
+0.50	.710	25	5.17	4.04	95.02	
+0.75	.600	30				
+1.00	.500	35	0.50	0.35	95.37	
+1.25	.425	40				
+1.50	.355	45	0.13	0.09	95.47	
+1.75	.300	50				
+2.00	.250	60	0.41	0.29	95.76	
+2.25	.212	70				
+2.50	.180	80	2.43	1.72	97.48	
+2.75	.150	100				
+3.00	.125	120	2.50	1.77	99.24	
+3.25	.106	1-0				
+3.50	.090	170	0.39	0.28	99.52	
+3.75	.075	200				
+4.00	.063	230	0.19	0.13	99.65	
	0.000	Pan	0.49	0.35	100.00	
	Totals		141.41			
	Gain or loss		-.69			

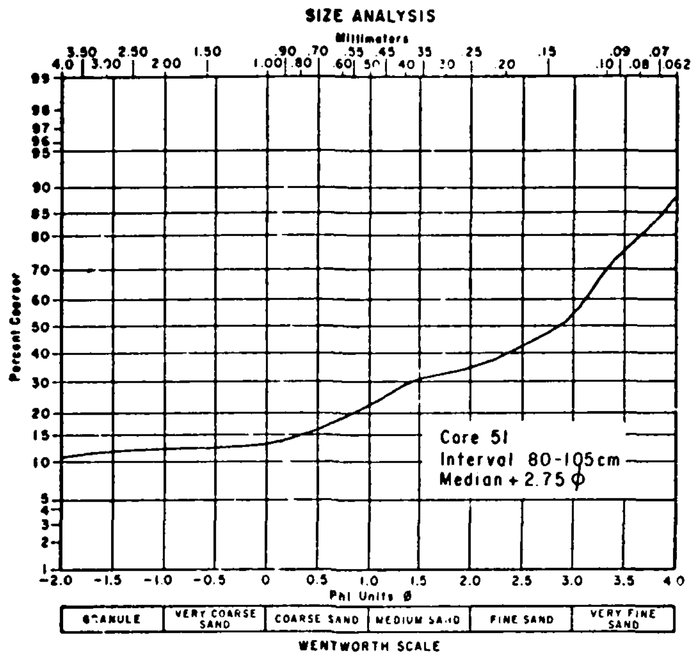
CERC SEDIMENT ANALYSIS

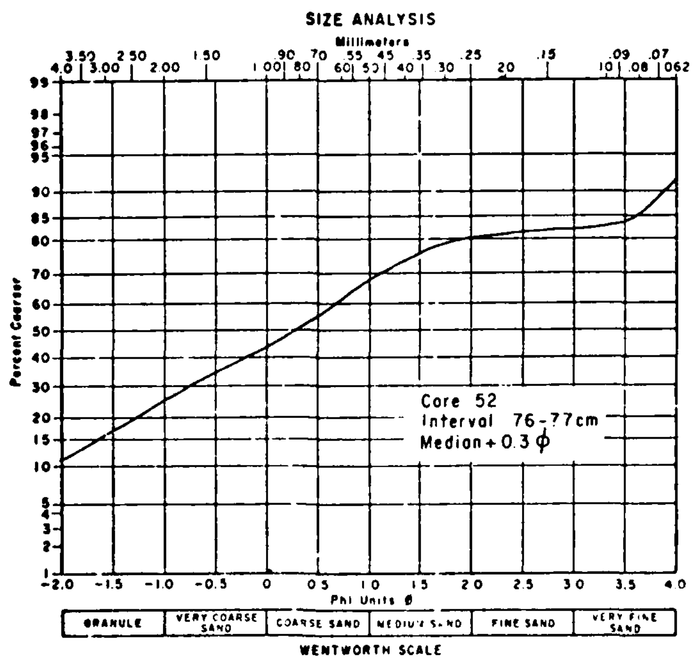
CERC C# 0094 Collected by ______ Date May 1979
Project ICONS LAKE ERIE - OHIO
Location/Sample No. ERIE, PA
Remarks CORE 94 100 - 110 cm

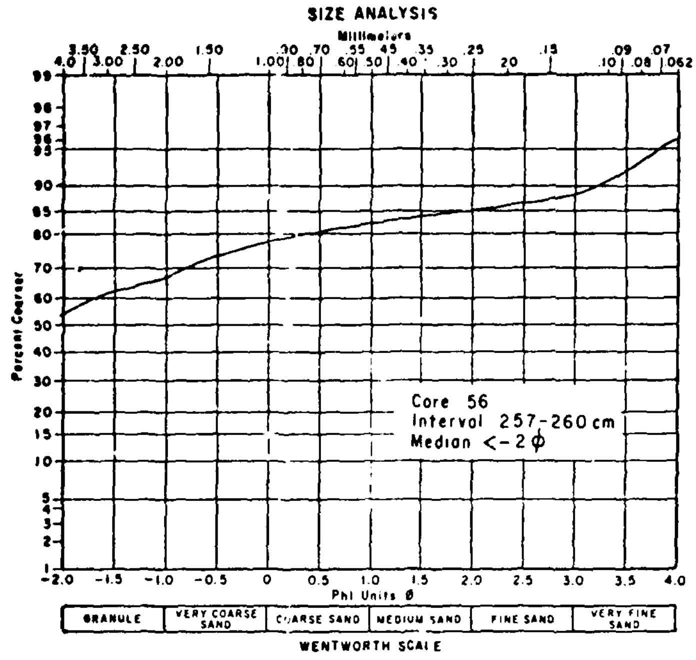
SIEVE ANALYSIS OF SAND

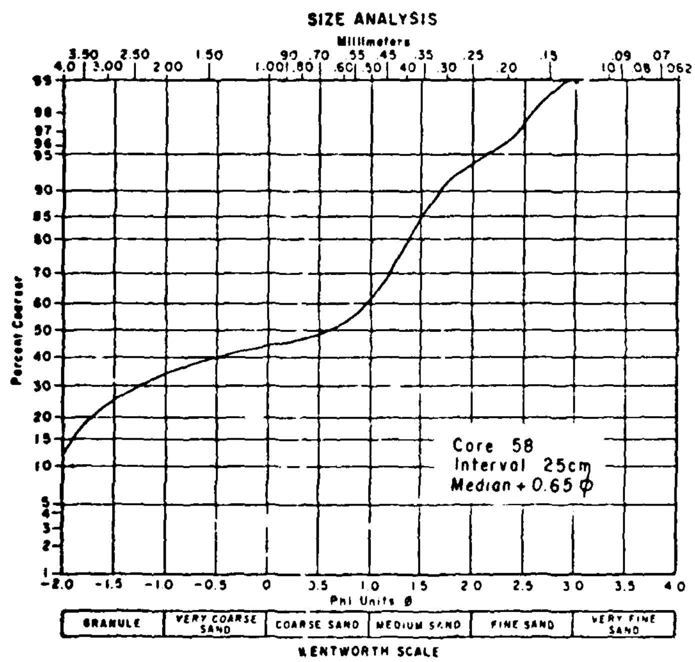
Weight of Sample 155.15 gr. Analyzed by ______ # Date ______

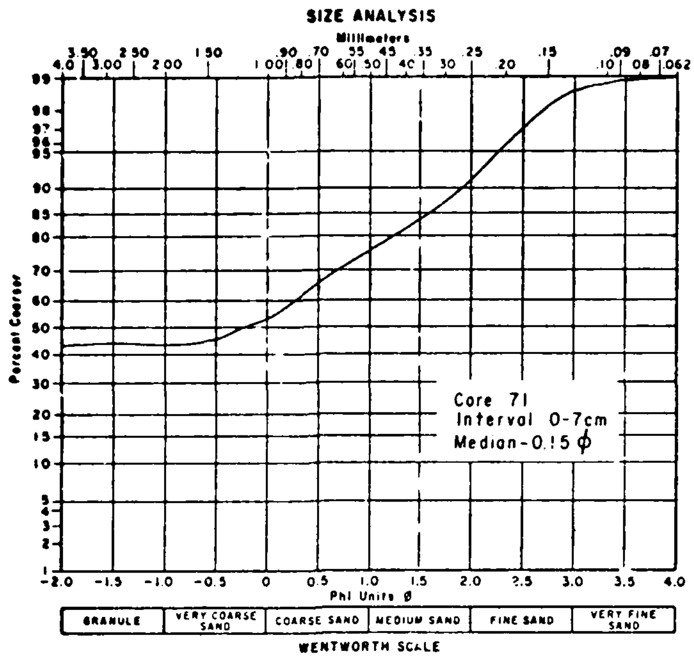
Φ	Screen Opening MM	U.S. Mesh Number	Retained on Sieves: Grams	Retained on Sieves: Per Cent	Retained on Sieves: Cumulative Per Cent	Cumulative Per Cent Passing
-6.67	26.670	1 3/64				
-5.60	22.400	7/8				
-4.80	19.200	3/4				
-4.00	16.000	5/8				
-3.68	13.550	1/2				
-3.50	11.100	7/16	3.16	2.33	2.33	
-3.25	9.520	3/8	3.23	2.09	4.42	
-3.00	7.930	5/16	6.60	4.27	4.69	
-2.65	6.350	1/4	10.89	7.04	15.74	
-2.50	5.613	3 1/2	4.81	3.11	18.84	
-2.25	4.760	4				
-2.00	3.962	5	12.70	8.21	27.06	
-1.75	3.360	6				
-1.50	2 794	7	12.59	8.14	35.20	
-1.25	2.362	8				
-1.00	2.000	10	12.70	8.21	43.42	
-0.75	1.700	12				
-0.50	1.400	14	20.55	13.29	56.71	
-0.25	1.190	16				
0.00	1.000	18	17.88	11.56	68.27	
+0.25	.850	20				
+0.50	.710	25	8.99	5.81	74.08	
+0.75	.600	30				
+1.00	.500	35	2.93	1.89	75.98	
+1.25	.425	40				
+1.50	.355	45	2.86	1.85	77.83	
+1.75	.300	50				
+2.00	.250	60	9.15	5.92	83.75	
+2.25	.212	70				
+2.50	.180	80	16.39	10.60	94.35	
+2.75	.150	100				
+3.00	.125	120	6.95	4.49	98.84	
+3.25	.106	140				
+3.50	.090	170	0.85	0.55	99.[illegible]	
+3.75	.075	200				
+4.00	.063	230	0.25	0.16	99.[illegible]	
	0.000	Pan	0.69	0.45	100.00	
	Totals		154.62			
	Gain or loss		-0.53			

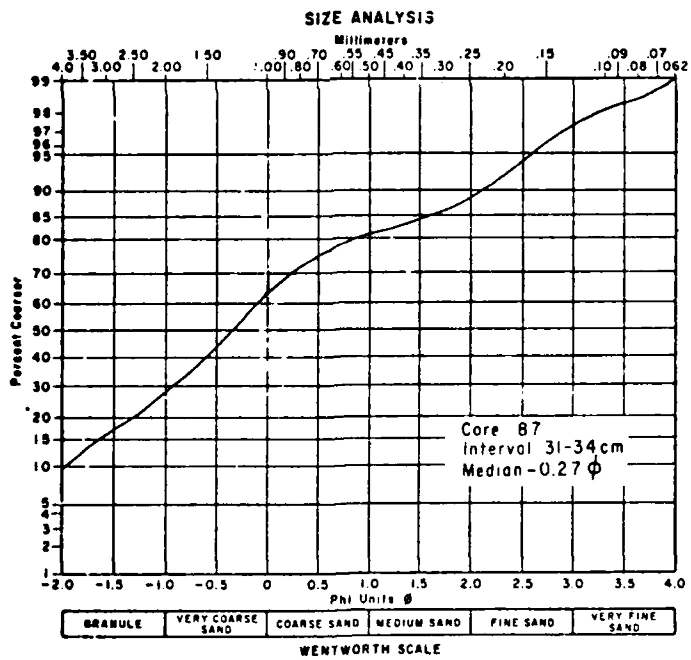

SIZE ANALYSIS
Millimeters
Percent Coarser
Core 51
Interval 80-105cm
Median + 2.75 φ
Phi Units ø
GRANULE
VERY COARSE SAND
COARSE SAND
MEDIUM SAND
FINE SAND
VERY FINE SAND
WENTWORTH SCALE

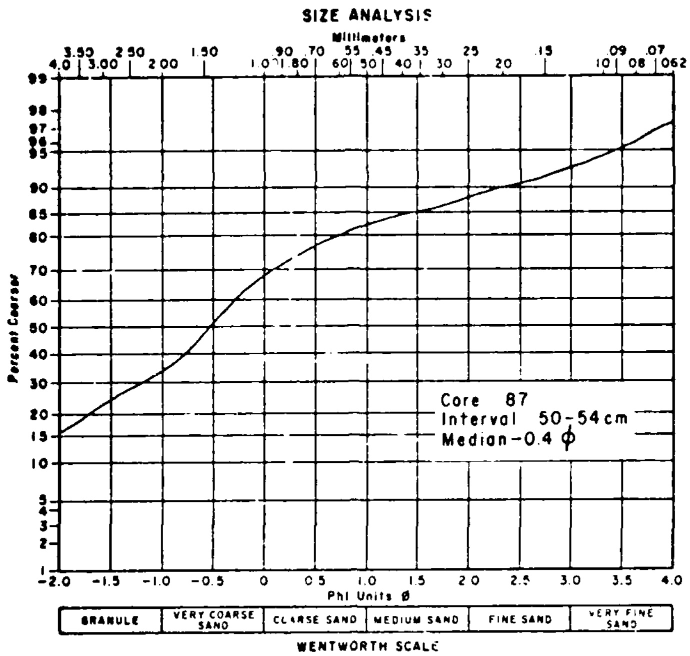

SIZE ANALYSIS
Millimeters
Percent Coarser
Core 52
Interval 76-77cm
Median + 0.3 φ
Phi Units ø
GRANULE
VERY COARSE SAND
COARSE SAND
MEDIUM SAND
FINE SAND
VERY FINE SAND
WENTWORTH SCALE

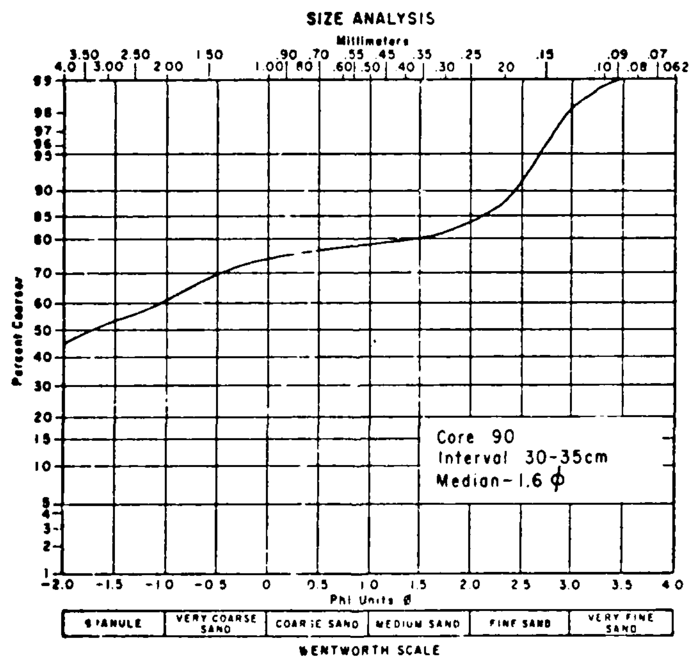

SIZE ANALYSIS
Millimeters
Percent Coarser
Phi Units ø
GRANULE
VERY COARSE SAND
COARSE SAND
MEDIUM SAND
FINE SAND
VERY FINE SAND
WENTWORTH SCALE
Core 56
Interval 257-260 cm
Median <-2 ϕ

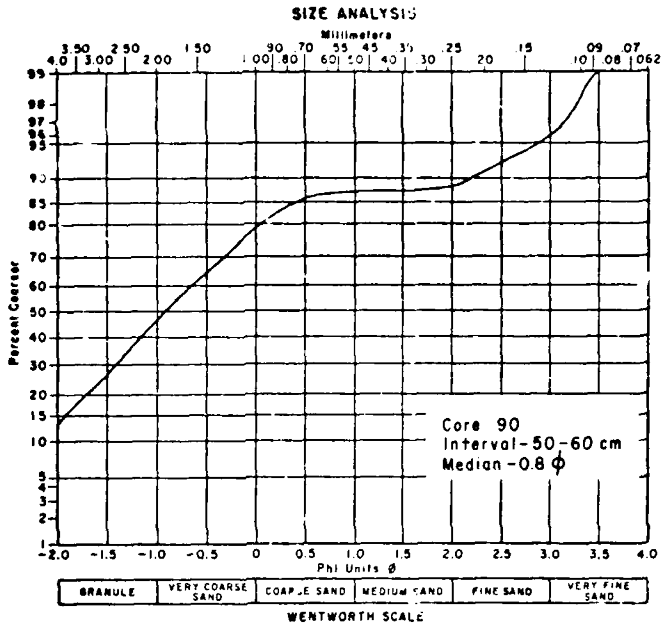

SIZE ANALYSIS
Millimeters
Percent Coarser
Phi Units ø
GRANULE
VERY COARSE SAND
COARSE SAND
MEDIUM SAND
FINE SAND
VERY FINE SAND
WENTWORTH SCALE
Core 58
Interval 25cm
Median + 0.65 ϕ

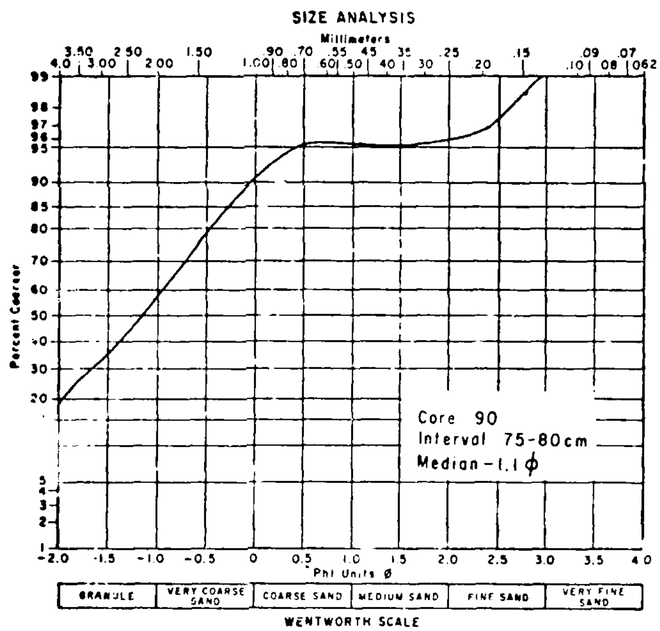

SIZE ANALYSIS
Millimeters
Percent Coarser
Phi Units ø
GRANULE
VERY COARSE SAND
COARSE SAND
MEDIUM SAND
FINE SAND
VERY FINE SAND
WENTWORTH SCALE
Core 71
Interval 0-7cm
Median-0.15 ϕ

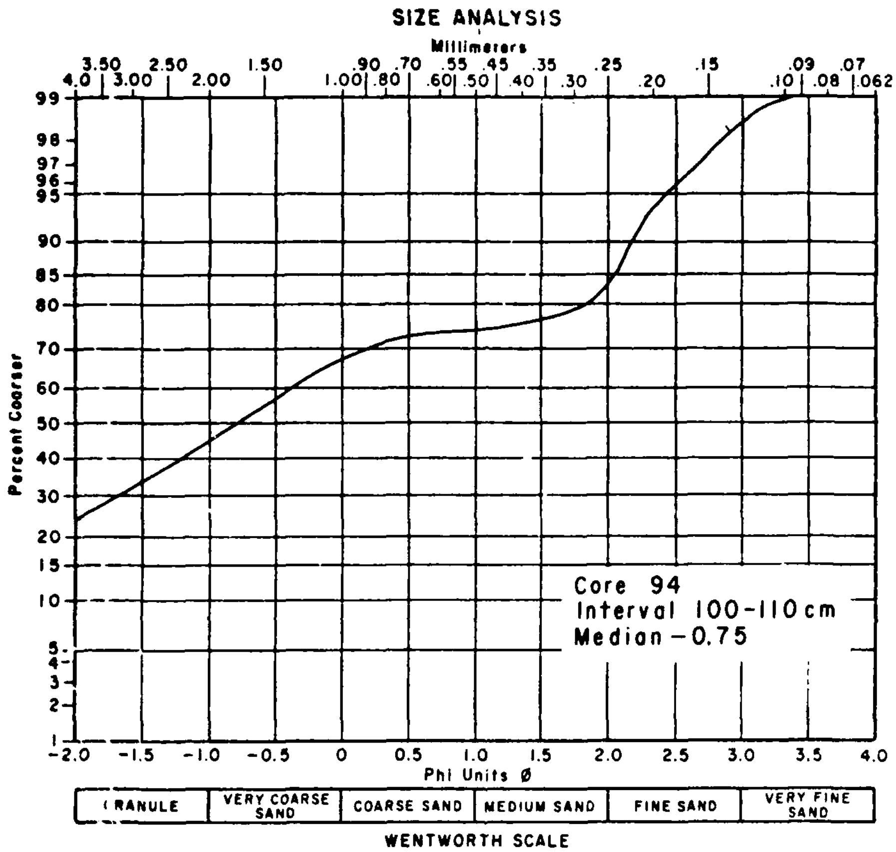

SIZE ANALYSIS
Millimeters
Percent Coarser
Phi Units ø
GRANULE
VERY COARSE SAND
COARSE SAND
MEDIUM SAND
FINE SAND
VERY FINE SAND
WENTWORTH SCALE
Core 87
Interval 31-34cm
Median-0.27 ϕ


SIZE ANALYSIS
Millimeters
Percent Coarser
Core 87
Interval 50-54cm
Median -0.4 φ
Phi Units Ø
GRANULE
VERY COARSE SAND
COARSE SAND
MEDIUM SAND
FINE SAND
VERY FINE SAND
WENTWORTH SCALE


SIZE ANALYSIS
Millimeters
Percent Coarser
Core 90
Interval 30-35cm
Median - 1.6 φ
Phi Units Ø
VERY COARSE SAND
MEDIUM SAND
FINE SAND
VERY FINE SAND
WENTWORTH SCALE


SIZE ANALYSIS
Millimeters
Percent Coarser
Phi Units Ø
GRANULE
VERY COARSE SAND
COARSE SAND
MEDIUM SAND
FINE SAND
VERY FINE SAND
WENTWORTH SCALE
Core 90
Interval-50-60 cm
Median -0.8 ϕ


SIZE ANALYSIS
Millimeters
Percent Coarser
Phi Units Ø
GRANULE
VERY COARSE SAND
COARSE SAND
MEDIUM SAND
FINE SAND
VERY FINE SAND
WENTWORTH SCALE
Core 90
Interval 75-80cm
Median -1.1 ϕ


SIZE ANALYSIS
Millimeters
3.50 2.50 1.50 .90 .70 .55 .45 .35 .25 .15 .09 .07
4.0 3.00 2.00 1.00 .80 .60 .50 .40 .30 .20 .10 .08 .062
99 98 97 96 95 90 85 80 70 60 50 40 30 20 15 10 5 4 3 2 1
Percent Coarser
Core 94
Interval 100-110cm
Median -0.75
-2.0 -1.5 -1.0 -0.5 0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Phi Units Ø
GRANULE
VERY COARSE SAND
COARSE SAND
MEDIUM SAND
FINE SAND
VERY FINE SAND
WENTWORTH SCALE

PIPET ANALYSIS

Core	INTERVAL (cm)	SAND (pct)	SILT (pct)	CLAY (pct)
44	60 to 70	18.38	74.92	6.7
	110 to 120	14.75	57.69	27.56
49	30 to 40	39.26	40.71	20.03
	200 to 210	1.75	67.8	30.45
	330 to 340	0.51	87.55	11.94
	400 to 410	2.17	90.12	7.64
55	30 to 40	1.79	63.1	35.11
	190 to 195	59.80	29.49	10.71
	380 to 390	11.57	67.66	20.77
	410 to 420	17.53	42.37	40.10
57	170 to 180	70.57	22.98	6.45
	270 to 280	50.37	42.2	7.43
	370 to 380	37.04	53.51	9.45
58	440 to 450	83.06	16.1	0.84
59	247 to 248	24.66	61.89	13.45
60	360 to 370	62.51	30.37	7.12
	470 to 480	35.88	52.99	11.13
	560 to 570	18.92	42.12	38.96
61	40 to 50	71.0	22.47	6.53
	100 to 102	69.7	23.5	6.7
	190 to 200	37.6	50.9	11.5
	280 to 282	9.75	74.82	15.53
	310 to 320	27.4	36.5	36.1
62	70 to 80	5.2	57.3	37.5
	160 to 170	26.8	58.4	14.8
	260 to 270	1.6	53.5	44.9
	320 to 330	61.62	25.43	12.95
65	50 to 60	8.38	60.91	30.71
	220 to 222	69.7	17.9	12.4
	340 to 350	2.99	67.86	29.15
	450 to 460	1.30	48.94	49.76
66	60 to 70	2.21	61.05	36.74
	150 to 160	29.01	46.55	24.44
	224 to 226	8.02	57.65	34.33
	350 to 360	5.31	59.15	35.54
	450 to 460	3.83	52.89	43.28
67	40 to 50	61.59	25.01	13.4
	170 to 180	51.7	30.7	17.6
	260 to 270	1.56	49.09	49.35
	360 to 370	1.1	54.4	44.5
	460 to 470	1.07	38.57	60.36
69	250 to 260	72.86	17.40	9.74
	340 to 350	53.29	34.98	11.73
	440 to 450	2.66	52.68	44.66
	540 to 550	1.37	49.2	49.43
72	10 to 20	7.96	80.21	11.83
	65 to 66	18.43	61.62	19.95
	150 to 160	11.77	62.02	26.21
	340 to 350	0.34	51.82	47.84
74	20 to 30	5.7	29.0	65.3
	285 to 295	5.7	26.0	68.3
	470 to 480	1.7	47.6	50.7
77	100 to 110	14.42	54.96	30.62
	525 to 535	18.01	41.08	40.91
79	60 to 63	32.05	49.8	18.15
	105 to 115	21.66	40.1	38.24
	300 to 310	23.26	39.66	37.08
81	200 to 210	1.1	73.5	25.4
	310 to 320	0.4	45.8	53.8
	400 to 410	11.8	37.7	50.5
83	40 to 45	20.95	52.54	26.51
	100 to 110	2.53	71.18	26.29
	475 to 485	2.05	60.50	37.45
84	250 to 260	30.35	67.84	1.81
	335 to 345	16.60	40.16	43.24
85	100 to 110	11.79	71.91	16.3
	370 to 380	6.18	77.64	16.18
	405 to 415	15.30	37.85	46.85
86	90 to 100	16.61	73.32	10.07
	240 to 250	15.84	41.02	43.14
87	100 to 110	13.18	77.36	9.46
	250 to 260	5.51	80.67	13.82
	550 to 560	4.82	79.90	15.28
88	60 to 70	10.66	60.12	29.22
	200 to 210	3.41	73.26	23.33
	400 to 410	3.85	43.94	52.21
89	330 to 340	48.41	36.00	15.59
	390 to 392	0.46	66.71	32.83
90	335 to 337	51.64	34.88	13.48
	500 to 510	2.43	80.95	16.62
91	105 to 107	52.30	30.32	17.38
	300 to 310	4.36	77.19	18.45
95	15 to 25	1.52	54.62	43.86
	80 to 90	0.92	71.35	27.73
	280 to 290	2.07	69.95	27.98
	390 to 392	30.29	57.72	11.99
	435 to 445	11.60	40.26	48.14
96	0 to 5	13.49	62.67	23.84
	66 to 67	0.41	77.56	22.03
	130 to 140	0.86	53.39	35.75
	200 to 210	0.98	57.34	41.68
	250 to 260	13.59	46.63	39.78
	285 to 295	10.92	51.93	37.51
	390 to 400	15.77	38.14	46.09
		10.52	38.35	51.13
	480 to 490	4.08	26.14	69.78
98	60 to 70	2.65	75.74	21.61
	155 to 165	5.76	78.97	15.27
	270 to 280	0.66	68.64	30.70
	315 to 325	19.20	44.45	36.35
99	30 to 40	2.12	75.88	22.00
	100 to 110	0.26	68.43	31.31
	250 to 260	16.85	42.88	40.27
	310 to 320	39.80	57.72	2.48
101	553 to 556	72	25	2
102	0 to 5	25	51	24
	138 to 141	52	47	1
	252 to 255	36	62	2
	332 to 335	2	74	24
	340 to 343	3	36	61
103	140 to 143	6	92	2
	161 to 163	22	75	1
	181 to 184	2	94	4
	207 to 209	3	94	3
	217 to 225	1	81	8
104	5 to 10	0	60	40
	64 to 69	22	62	16
	95 to 105	21	64	15
	36 to 141	5	74	21
	149 to 150	40	55	5
	202 to 206	4	80	16
	300 to 305	T[1]	63	37
105	20 to 25	54	36	10
	50 to 80	58	39	3
	99 to 104	15	81	4
	160 to 165	7	76	17
	262 to 265	7	76	17
	275 to 280	0	66	34
	327 to 330	0	76	24
106	12 to 15	55	43	2
	81 to 94	20	73	7
	171 to 173	6	90	4
	354 to 359	7	52	41
	426 to 429	9	49	42
107	0 to 5	20	65	15
	33 to 36	42	57	1
	70 to 80	65	35	0
	131 to 135	76	24	0
	135 to 139	57	42	1
	362 to 365	T[1]	82	17
	369 to 372	4	49	47

[1]Trace amount.

VISUAL ACCUMULATION TUBE (VAT)

Core	INTERVAL (cm)	>4 phi (pct)	<4 phi (pct)	MEAN phi	STANDARD DEVIATION
101	45 to 60	84	16	3.9	0.7
	130 to 140	82	19	3.8	0.6
	180 to 200	91	9	3.6	0.6
103	0 to 5	98	2	2.8	0.7
106	7 to 10	95	5	3.1	0.7

Williams, S. Jeffress
Sand resources of southern Lake Erie, Conneaut to Toledo, Ohio - a seismic reflection and vibracore study / by S. Jeffress Williams, Charles H. Carter, [et al.]. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1980.
[83] p. : ill. : 27 cm. -- (Miscellaneous report -- U.S. Coastal Engineering Research Center ; no. 80-10)
Includes bibliographical references.
About 2,250 square kilometers of the Lake Erie bottom between Conneaut and Toledo, about 25 percent of Ohio's open lake part of Lake Erie, was surveyed to assess potential sand and gravel resources. Survey limits were from the -7.5-meter depth to about the -14-meter depth, a maximum of about 16 kilometers offshore.
1. Geomorphology. 2. Lake Erie. 3. Toledo, Ohio. 4. Sand resources. 5. Sediments. 6. Seismic reflection. I. Title. II. Carter, Charles H. III. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 80-10.
TC203 .U581mr no. 80-10 627

Williams, S. Jeffress
Sand resources of southern Lake Erie, Conneaut to Toledo, Ohio - a seismic reflection and vibracore study / by S. Jeffress Williams, Charles H. Carter, [et al.]. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1980.
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1. Geomorphology. 2. Lake Erie. 3. Toledo, Ohio. 4. Sand resources. 5. Sediments. 6. Seismic reflection. I. Title. II. Carter, Charles H. III. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 80-10.
TC203 .U581mr no. 80-10 627

Williams, S. Jeffress
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1. Geomorphology. 2. Lake Erie. 3. Toledo, Ohio. 4. Sand resources. 5. Sediments. 6. Seismic reflection. I. Title. II. Carter, Charles H. III. Series: U.S. Coastal Engineering Research Center. Miscellaneous report no. 80-10.
TC203 .U581mr no. 80-10 627

Williams, S. Jeffress
Sand resources of southern Lake Erie, Conneaut to Toledo, Ohio - a seismic reflection and vibracore study / by S. Jeffress Williams, Charles H. Carter, [et al.]. -- Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1980.
[83] p. : ill. : 27 cm. -- (Miscellaneous report -- U.S. Coastal Engineering Research Center ; no. 80-10)
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TC203 .U581mr no. 80-10 627

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